Volume 2 of 2
Project Manual

Master Plan Phase III Renovations and Additions
Norwalk Community College
188 Richards Avenue
Norwalk, CT
Project No.: BI-CTC-467

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VOLUME 1 of 2

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Piping materials and installation instructions common to most piping systems.

B. Mechanical sleeve seals.

C. Sleeves.

D. Escutcheons.

E. Grout.

F. Fire-suppression equipment.

G. Equipment installation requirements common to equipment sections.

H. Painting and finishing.

I. Concrete bases.

J. Supports and anchorages.

1.3 RELATED REQUIREMENTS

A. Section 01 91 00 - General Commissioning Requirements.

B. Section 21 08 00 - Commissioning of Fire Suppression.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Mechanical sleeve seals.
2. Escutcheons.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE AND FITTINGS

A. Refer to individual Division 21 piping sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 21 piping sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B800.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.
e. Link-Seal.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT

A. Description: ASTM C1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 21 sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Section 07 62 00 for flashing.

        1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 00 for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other sections of these specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 21 sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in Section 09 90 00.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 12 00 for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.6 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire-suppression materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.7 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 00 and 21 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 00 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 00 and 21 08 00 and manufacturer's written instructions/requirements.

3.9 FM Global Contractor's Material & Test Certificate for Automatic Sprinkler Systems:

A. Upon completion of work, inspection and tests shall be made by the contractor and witnessed by an Owner's representative. All defects shall be corrected and system left in service before the contractor's personnel finally leave the job.

B. A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owner and contractor. It is understood the owner's representatives signature in no way prejudices any claim against the contractor for faulty material, poor workmanship or failure to comply with authority's requirements or local ordinances.

C. Contractor shall use the following certificate:

FM Global Contractor's Material & Test Certificate for Automatic Sprinkler Systems

Additional printed copies of this form are available to clients from:
Communication Services, FM Global, 270 Central Avenue, Johnston, RI 02919

Procedure: Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners and contractor. It is understood the owner's representatives signature in no way prejudices any claim against the contractor for faulty material, poor workmanship or failure to comply with approving authority's requirements or local ordinances.

Contractor Information	Date:
Contractor Company Name:	
Contractor Company Address:	

FM Global Client Information	FM Global Index No.:	FM Global Account No.:
FM Global Client Building Owner or Tenant (Y/N)?	Building Name or No.:	
FM Global Client Name:		
FM Global Client Address:		
Description of Occupancy Being Protected:		

Automatic Sprinkler System Components and Materials

Automatic Sprinklers:

Manufacturer	Model / Trade Name	K-Factor	Temperature Rating	SIN	Year of Manufacture	Quantity

Automatic Sprinkler Pipe:

Manufacturer	Model / Trade Name	Product Description	Schedule	Connection Type	Max. Working Pressure

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Automatic Sprinkler System Components and Materials (cont.)				
Automatic Sprinkler Pipe Connection:				
Manufacturer	**Model / Trade Name**	**Product Description**	**Pipe Ends**	**Max. Working Pressure**

Automatic Sprinkler Pipe Hangers:					
Manufacturer	**Model / Trade Name**	**Product Description**	**Hanger Rod Size**	**Component Description**	**Nominal Pipe Size**

Automatic Sprinkler System Alarm-Check, Dry-Pipe or Automatic-Release Type Valves:				
Type	**Manufacturer**	**Model**	**Serial Number**	**Quantity**

If Automatic-Release Type Valve:
Is the detection electronic, hydraulic and/or pneumatic?
Is the interlock arrangement single, double or non-interlock?
Is the air pressure in the system piping supervised?
Is the Automatic-Release Valve arranged for manual operation?

Detection for Automatic-Release Type Valves:						
Type	**Manufacturer**	**Model**	**Protected Area**	**Linear Spacing**	**Area Spacing**	**Quantity**

If the Detection for Automatic-Release Type Valve is electric:
Is the circuitry supervised in accordance with Data Sheet 5-40?
What is make and model of Automatic Release Control Panel?
What is make and model of Solenoid Release Valve?

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Automatic Sprinkler System Components and Materials (cont.)				
Automatic Sprinkler System Control or Pressure-Reducing Type Valves:				
Type	**Manufacturer**	**Model**	**Serial Number**	**Quantity**
Automatic Sprinkler System Check or Backflow Preventer Type Valves:				
Type	**Manufacturer**	**Model**	**Serial Number**	**Quantity**

Automatic Sprinkler System – Miscellaneous Components:			
Component	**Manufacturer**	**Model**	**Quantity**
Waterflow Alarm			
Quick Opening Device			
Pressure Gauge			
Fire Department Connection			
Relief Valve			
Test Connection			
Drain Valve			

Automatic Sprinkler System – Other Components:			
Component	**Manufacturer**	**Model**	**Quantity**

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Automatic Sprinkler System Tests

Hydrostatic Tests: Hydrostatic tests shall be conducted at not less than 200 psi (13.8 bar) or 50 psi (3.5 bar) above any static pressure in excess of 150 psi (10.3 bar) for 2 hours. Hydrostatically test any anti-freeze solution sprinkler systems equipped with pendent sprinklers with the anti-freeze solution being used. Differential dry-pipe valves clappers shall be left open during the test to prevent damage. Modify the automatic sprinkler as needed to ensure there is no pressure drop over the 2 hour timeframe.

The sprinkler piping for all wet-pipe automatic sprinkler systems as well as anti-freeze solution automatic sprinkler systems equipped with pendent sprinklers have been hydrostatically tested at _____ psi for _____ hours with _____ psi drop.

Pneumatic Tests: Pneumatic tests shall be conducted at not less than 40 psi (2.8 bar) air pressure. Ensure pressure tanks are arranged for their normal water level and air pressure conditions. Modify the automatic sprinkler system as needed to ensure there is no more than a 1.5 psi (0.1 bar) pressure drop over a 24 hour timeframe.

The sprinkler piping for all dry-pipe and similar automatic sprinkler systems have been pneumatically tested at _____ psi for _____ hours with _____ psi drop.

Waterflow Alarm Tests: Tests shall be conducted on all automatic sprinkler system alarm devices to ensure that an alarm signal is activated no more than 60 seconds after initiating waterflow through the Inspector's Test Connection or similar device.

A total of _____ waterflow alarm devices were tested. A total of _____ waterflow alarm devices activated an alarm signal in more than 60 seconds.

Dry Pipe System or Automatic-Release Type System Testing:

System No./Name	Water Pressure Below Valve	System Air Pressure	Min. Pressure Req. at Sprinkler	Required Water Delivery Time	Time to Achieve Minimum Required Sprinkler Pressure: Without Q.O.D.	With Q.O.D.

If Automatic-Release Type Valve:

Was valve operated manually as well as automatically?

If Detection is electronic, were all detection units tested?

Pressure-Reducing Valve Testing:

Location	Make	Model	Setting	Static Pressure		Residual Pressure		Flow Rate
				Inlet	Outlet	Inlet	Outlet	

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Automatic Sprinkler System Tests (cont.)		
Blank Testing Gaskets:		
Number Used	**Location**	**Number Removed**

Welded Pipe Connections:	**Yes or No?**
Do you certify as the sprinkler contractor that the welding procedures used for the connection of sprinkler piping materials complied with the minimum requirements of AWS B2.1, ASME Section IX *Welding and Brazing Qualifications*, or other applicable qualification standards as required by the AHJ?	
Do you certify that all welding procedures used for the connection of sprinkler piping materials was conducted by welders or welding operators qualified in accordance with the minimum requirements of AWS B2.1, ASME Section IX *Welding and Brazing Qualifications*, or other applicable qualification standards as required by the AHJ?	
Do you certify that the welding was carried out in compliance with a documented quality control procedure to ensure that all discs and field-cut pipe coupons were retrieved from the sprinkler system piping, that openings in piping are smooth, that slag and other welding residue were removed, and that internal diameters of piping were not penetrated?	

Drain Tests:

System Name/No.	Static Pressure	Residual Pressure	Static Pressure Afterwards

Underground Mains:

All underground mains and lead-in connections to automatic sprinkler system risers shall be flushed before connection is made to automatic sprinkler system piping.

Was this verified on Form FM85B?	If No, what form was used?
What contractor flushed the underground mains and lead-ins?	

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Automatic Sprinkler System Tests (cont.)	
Instruction Materials:	**Yes or No?**
Has the person in charge of the fire equipment been instructed as to the location of all the automatic sprinkler system control valves and the care and maintenance of this new equipment?	
Have copies of the appropriate instructions and care of maintenance charts been left on the premises?	
If the answer to either of these questions is "No", explain:	
Date Sprinkler System Left in Service With All Control Valves Open:	
Signatures:	
The Property Owner or their authorized agent:	
Signature and Title	**Date**
The Sprinkler Contractor:	
Signature and Title	**Date**
Additional Explanations, Comments and/or Notes:	

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END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Isolation mounts.

B. Restrained elastomeric isolation mounts.

C. Restraining braces.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California

D. NFPA: National Fire Protection Association.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined on the Structural Drawing.
2. Assigned Seismic Use Group or Building Category as Defined on the Structural Drawings.

    a. Component Importance Factor: Refer to ASCE-7-02.
    b. Component Response Modification Factor: Refer to ASCE-7-02.
    c. Component Amplification Factor: Refer to ASCE-7-02.

3. Design Spectral Response Acceleration at Short Periods: Refer to Structural Drawing.
4. Design Spectral Response Acceleration at Refer to Structural Drawing.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Welding certificates.

E. Qualification Data: For professional engineer and testing agency**.**

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing

laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC and NFPA 13 unless requirements in this section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries.
3. Hilti, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. TOLCO Incorporated; a brand of NIBCO INC.
7. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

F. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488. Minimum length of eight (8) times diameter.

I. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127 and NFPA 13.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 21 10 00 for piping flexible connections.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. Section 01 91 00 – General Commissioning Requirements

B. Division 21 – Fire Suppression

C. Division 28

1.3 REQUIREMENTS

A. The Commissioning process requires the participation of Division 21 "Fire Suppression" to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 21 "Fire Suppression" shall fulfill commissioning responsibilities assigned to Division 21 in accordance with Section 01 91 00.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.

B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with Section 01 91 00.

C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. The intent of functional testing is to verify system operation is in accordance with design intent. Thorough test procedures will be utilized to verify systems and equipment through their full sequence of operations..

B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with Section 01 91 00.

C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 21 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.
   1. Fire Protection System and Equipment; fire alarm system interface with HVAC systems.

3.4 SAMPLE CHECKLISTS

A. See Attached.

Functional Test

FIRE PROTECTION SYSTEMS

1. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

2. Prerequisite Checklist

a. All associated equipment/systems including piping and fire alarm system have been installed and are ready for functional testing.
b. All A/E punch list items for this equipment corrected.
c. Safeties and operating ranges reviewed.

d. This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
e. This checklist does not take the place of the Authority Having Jurisdiction's (AHJ) required tests under AHJ's supervision.
f. All fire protection systems are installed per the shop drawings.
g. The Engineer of record and the Owner's insurance underwriter has approved all fire protection shop drawings including hydraulic calculations.
h. Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
i. Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check if Okay. Enter comment or note number if deficient.

Check	
Zone Valves	
Sealed	
Locked	
Tamper Switches	
Position	
Operation	
Supervisory	
Alarm Valves	
Pressure gauges	
Main drain/test	
Trim piping per manufacturer's instructions	
Isolation valve	
Backflow Prevention	
Reduced Pressure Backflow Preventer	
Reduced pressure Detectors Assembly	
Double Check Valve Assembly	
Double Check Detector Assembly	
Fire Department Connection	
Brass Finish	
Brass caps and chains	
Check valve	
Waterflow Alarms	
Tied into fire alarm control panel	

Provided at alarm valve riser	
Valves, Piping	
Isolation valves installed per drawings	
Pipe fittings complete and pipes properly supported	
Pipes properly labeled	
Piping system properly flushed	
No leaking apparent around fittings	
Valves properly labeled	
Risers clamps	
Test connections	
Instrumentation installed according to specification (pressure gages, test valves, etc.)	
Clean up of equipment completed per contract documents	
Inspectors test connections provided at all zones with equivalent sprinkler orifice size	
Maintenance access acceptable for components	

The checklist items of Part 3 are all successfully completed for given trade ☐ ***YES*** ☐ ***NO***

4. Operational Checks

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	**Test Results Functional Y/N**
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 1	
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 2	
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 3	

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	**Test Results Functional Y/N**
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 4	
Activation of tamper switch and automatic activation of alarm at fire alarm control panel at all valve locations	

The checklist items of Part 4 are all successfully completed for given trade ☐ YES ☐ NO

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Pipes, fittings, and specialties.

B. Fire-protection valves.

C. Fire-department connections.

D. Alarm devices.

E. Pressure gages.

1.3 RELATED SECTIONS

A. Section 21 13 13 - Wet-Pipe Sprinkler Systems: Wet-pipe sprinkler piping.

B. Section 28 31 11 - Digital, Addressable Fire-Alarm System: Alarm devices not specified in this section.

1.4 DEFINITIONS

A. High-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

B. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig maximum.

1.5 SYSTEM DESCRIPTIONS

A. Automatic Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has water supply to maintain water and sprinkler system pressure in combination sprinkler/standpipe and standard standpipes. System piping shall be

hydraulically calculated to meet the flow and pressure requirements outlined in NFPA-14 and The IBC.

1.6 PERFORMANCE REQUIREMENTS

A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.

B. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.

1. Minimum residual pressure at each hose-connection outlet is as follows:

a. NPS 2-1/2 Hose Connections: 100 psig.

2. Maximum residual pressure at required flow at each hose-connection outlet is as follows unless otherwise indicated:

a. NPS 2-1/2 Hose Connections: 175 psig.

D. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7 and Section 21 05 48.

1.7 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For fire-suppression standpipes. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design Submittal: For standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

E. Coordination Drawings: Fire-suppression standpipes, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.
2. Drainage piping.
3. HVAC hydronic piping.
4. Ductwork.
5. Lighting

F. Qualification Data: For qualified Installer and professional engineer.

G. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

H. Welding certificates.

I. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

J. Field quality-control reports.

K. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on the requirements outlined in NFPA-14 and The IBC.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14, "Installation of Standpipe and Hose Systems."

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

A. Schedule 10, Black-Steel Pipe: (Wet Standpipe) ASTM A135 or ASTM A795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

B. Malleable- or Ductile-Iron Unions: UL 860.

C. Cast-Iron Flanges: ASME B16.1, Class 125.

D. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

E. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

   a. Corcoran Piping System Co.
   b. National Fittings, Inc.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.

2. Pressure Rating: 175 psig minimum.
3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A47, malleable-iron casting or ASTM A536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.

3. Minimum Pressure Rating for High-Pressure Piping: 250 psig.

B. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

   a. Victaulic Company
   b. Nibco
   c. Watts

2. Standard: UL 312.
3. Pressure Rating: 250 psig minimum.
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.

C. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

   a. Victaulic Company
   b. Nibco
   c. Watts

2. Standard: UL 262.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

D. Indicating-Type Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

   a. Victaulic Company
   b. Nibco
   c. Watts

2. Standard: UL 1091.
3. Pressure Rating: 175 psig minimum.
4. Valves NPS 2 and Smaller:

a. Valve Type: Ball or butterfly.
b. Body Material: Bronze.
c. End Connections: Threaded.

5. Valves NPS 2-1/2 and Larger:

a. Valve Type: Butterfly.
b. Body Material: Cast or ductile iron.
c. End Connections: Flanged, grooved, or wafer.

6. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch and visual indicating device.

2.4 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psig minimum.

B. Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

a. Victaulic Company
b. Nibco
c. Watts

C. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

a. Victaulic Company
b. Nibco
c. Watts

2.5 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory listing" or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:

    a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
    b. High-Pressure Piping Specialty Valves: 250 psig minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

    a. Victaulic Company
    b. Nibco
    c. Watts

2. Standard: UL 1726.
3. Pressure Rating: 175 psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.6 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Fire-End & Croker Corporation.
    c. Potter Roemer.

2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA and matching local fire-department threads.
8. Pattern: Angle.

9. Finish: Polished chrome plated

2.7 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Potter Electric Signal Company.
   c. System Sensor; a Honeywell company.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.8 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following manufacturers offering products that may be incorporated into the Work:

1. AMETEK; U.S. Gauge Division.
2. Ashcroft Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 psig minimum.

E. Water System Piping Gage: Include "WATER" label on dial face.

2.9 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated finish with set-screws.

C. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw.

E. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated finish with concealed hinge and set-screw.

F. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

G. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.10 SLEEVES

A. Cast-Iron Wall-Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A53, Type E, standard weight, zinc coated, plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set-screws.

2.11 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. Metraflex, Inc.
3. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.12 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" article.

B. Report test results promptly and in writing.

3.2 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 WATER-SUPPLY CONNECTIONS

A. Connect fire-suppression wet standpipe piping to building's interior sprinkler entrance distribution piping.

B. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.4 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install drain valves on standpipes. Extend drain piping to outside of building.

F. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.

G. Install alarm devices in piping systems.

H. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

I. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

J. Fill wet-type standpipe system piping with water.

3.5 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

K. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.6 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

3.7 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2.

D. Install standpipe mounted type hose connections. Install valves at angle required for connection of fire hose. Coordinate location of valve and standpipe with “Area of Refuge” and adjacent steel.

3.8 TEMPORARY STANDPIPES DURING CONSTRUCTION

A. Temporary standpipes shall be provided during construction. Temporary standpipes may be the final installation piping system used for this purpose.

B. Installation shall conform to NFPA-14 and The IBC 2003.

3.9 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One (1) piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One (1) piece, cast brass with polished chrome-plated finish stamped steel with set-screw stamped steel with set-screw or spring clips stamped steel with spring clips.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One (1) piece, cast brass with polished chrome-plated finish One (1) piece or split casting, cast brass with polished chrome-plated finish Split casting, cast brass with polished chrome-

plated finish One (1) piece, stamped steel with set-screw One (1) piece or split plate, stamped steel with set-screw Split plate, stamped steel with set-screw.

4. Bare Piping in Unfinished Service Spaces: One (1) piece, cast brass with polished chrome-plated finish cast brass with rough-brass finish stamped steel with set-screw stamped steel with spring clips stamped steel with set-screw or spring clips.
5. Bare Piping in Equipment Rooms: One (1) piece, cast brass stamped steel with set-screw stamped steel with spring clips stamped steel with set-screw or spring clips.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.10 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Section 07 92 00.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Section 07 92 00.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized-steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Stack sleeve fittings.

a. Extend sleeves two (2) inches above finished floor level.
b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level. Comply with requirements for flashing in Section 07 62 00.

3. Sleeves for Piping Passing through Concrete Roof Slabs: Galvanized-steel pipe.
4. Sleeves for Piping Passing through Exterior Concrete Walls:

a. Galvanized-steel-pipe sleeves for pipes smaller than NPS 6.
b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
c. Install sleeves that are large enough to provide 1-inchannular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

5. Sleeves for Piping Passing through Interior Concrete Walls:

a. PVC-pipe Galvanized-steel-pipe sleeves for pipes smaller than NPS 6.
b. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Section 07 84 13.

3.11 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.12 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53.

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Verify that equipment hose threads are same as local fire-department equipment.

C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.14 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.15 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 4 to NPS 8 shall be the following:

1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-pressure, dry-type, fire-suppression standpipe piping, NPS 4 TO NPS 8, shall be the following:

1. Schedule 10, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Pipes, fittings, and specialties.

B. Fire-protection valves.

C. Fire-department connections.

D. Sprinklers.

E. Excess-pressure pumps.

F. Alarm devices.

G. Pressure gages.

1.3 RELATED REQUIREMENTS

A. Section 01 91 13 - General Commissioning Requirements.

B. Section 21 08 00 - Commissioning of Fire Suppression.

1.4 DEFINITIONS

A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

1.5 REFERENCES

A. National Fire Protection Association (NFPA):

1. NFPA 13-2002, Standard for the Installation of Sprinkler Systems.
2. NFPA 70-2011, National Electrical Code.

1.6 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.

1.7 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. Delegated Design: Design sprinkler system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Provide fire-hydrant flow test indicating the following conditions:

a. Date:
b. Time:
c. Performed by:
d. Location of Residual Fire Hydrant R:
e. Location of Flow Fire Hydrant F:
f. Static Pressure at Residual Fire Hydrant R:
g. Measured Flow at Flow Fire Hydrant F:
h. Residual Pressure at Residual Fire Hydrant R:

C. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:
   a. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   b. General Storage Areas: Ordinary Hazard, Group 1.
   c. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   d. Office and Public Areas: Light Hazard.
   e. General Classrooms: Light Hazard.
   f. Science Classrooms, Prep Rooms and Science Storage: Ordinary Hazard Group 1.

3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq ft area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq ft area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq f**t** area.

4. Maximum Protection Area per Sprinkler: Per UL listing.

5. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq ft.
   b. Storage Areas: 130 sq ft.
   c. Mechanical Equipment Rooms: 130 sq ft.
   d. Electrical Equipment Rooms: 130 sq ft.
   e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

6. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.8 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

   1. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

E. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Domestic water piping.
   2. Compressed air piping.
   3. HVAC hydronic piping.
   4. Items penetrating finished ceiling include the following:

      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.

F. Qualification Data: For qualified Installer and professional engineer.

G. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

H. Welding certificates.

I. Fire-hydrant flow test report.

J. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

K. Field quality-control reports.

L. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.10 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then

only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Construction Manager/Owner no fewer than two (2) days in advance of proposed interruption of sprinkler service.
2. Do not proceed with interruption of sprinkler service without Construction Manager's Owner's written permission.

1.11 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on project.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

A. Standard Weight, Black-Steel Pipe: ASTM A53, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 10, Black-Steel Pipe: ASTM A135 or ASTM A795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

C. Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53, standard-weight, seamless steel pipe with threaded ends.

D. Malleable- or Ductile-Iron Unions: UL 860.

E. Cast-Iron Flanges: ASME 16.1, Class 125.

F. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

G. Steel Welding Fittings: ASTM A234 and ASME B16.9.

H. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
   a. Anvil Victaulic Company.
   b. Wheatland Inc.
   c. National Fittings, Inc.
   d. Tyco Fire & Building Products LP.

2. Pressure Rating: 175 psig minimum.
3. Grooved-End Fittings for Steel Piping: ASTM A47, malleable-iron casting or ASTM A536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.

B. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following;

   a. Anvil International, Inc.
   b. Victaulic Company.
   c. Millwaukee.
   d. NIBCO INC.

2. Standard: UL 1091 except with ball instead of disc.
3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
4. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.

5. Valves NPS 3: Ductile-iron body with grooved ends.

C. Iron Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Tyco Fire & Building Products LP.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig.
4. Body Material: Cast or ductile iron.
5. Style: Lug or wafer.
6. End Connections: Grooved.

D. Check Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Tyco Fire & Building Products LP.

2. Standard: UL 312.
3. Pressure Rating: 250 psig minimum.
4. Type: Swing check.
5. Body Material: Cast iron.
6. End Connections: Flanged or grooved.

E. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Valve, Inc.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Watts Water Technologies, Inc.

2. Standard: UL 262.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Cast or ductile iron.

5. End Connections: Flanged or grooved.

F. Indicating-Type Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Tyco Fire & Building Products LP.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig minimum.
4. Valves NPS 2 and Smaller:

   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.

5. Valves NPS 2-1/2 and Larger:

   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged, grooved, or wafer.

6. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch visual indicating device.

2.4 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 psig minimum.

B. Angle Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Fire Protection Products, Inc.
   b. United Brass Works, Inc.
   c. NIBCO.

C. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Watts Water Technologies, Inc.

D. Globe Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Fire Protection Products, Inc.
   b. Milwaukee Valve Company.
   c. NIBCO.

2.5 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:

   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company
   b. Tyco Fire & Building Products LP.
   c. Milwaukee Valve Company.

2. Standard: UL 193.
3. Design: For horizontal or vertical installation.

4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. AFAC Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.

2. Standard: UL 1726.
3. Pressure Rating: 175 psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

D. Backflow Preventer:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Watts
   b. Ames
   c. ZURN

2. Standard: AWWA C510-97 UL Listed FM Approved
3. Design: Double Check Detector Assembly Backflow
4. Include OSY Valves with tamper switches, 300 series stainless steel internal metal parts,

2.6 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Victaulic Company

b. Tyco Fire & Building Products LP.
c. Anvil International, Inc.

2. Standard: UL 213.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Victaulic Company.
   b. Tyco Fire & Building Products LP.
   c. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. CECA, LLC.
   b. Corcoran Piping System Co.
   c. Merit Manufacturing; a division of Anvil International, Inc.

2. Standard: UL 1474.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

D. Flexible, Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. VicFlex, Victaulic
    b. FlexHead Industries, Inc.
    c. AquaFlex

2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175 psig minimum.
5. Size: Same as connected piping, for sprinkler.

2.7 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    1. Victaulic Company.
    2. Tyco Fire & Building Products LP.
    3. Viking Corporation.

B. General Requirements:

    1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
    2. Pressure Rating for Residential Sprinklers: 175 psig maximum.
    3. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
    4. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

    1. Early-Suppression, Fast-Response Applications: UL 1767.
    2. Nonresidential Applications: UL 199.
    3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes:

    1. Chrome plated.
    2. Bronze.
    3. Painted.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel**,** flat.

F. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco Fire & Building Products LP.
   c. Victaulic Company.
   d. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.8 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Potter Electric Signal Company.
   d. System Sensor; a Honeywell company.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.9 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Ashcroft, Inc.
   2. Brecco Corporation.
   3. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0 to 250 psig minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

2.10 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated finish with set-screws.

C. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw.

E. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated finish with concealed hinge and set-screw.

F. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed set-screw.

G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.11 SLEEVES

A. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A53, Type E, standard weight, zinc coated, plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set-screws.

2.12 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. Pro-Set.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.13 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" article.

B. Report test results promptly and in writing.

3.2 WATER-SUPPLY CONNECTIONS

A. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Install backflow minimum 3’-0” above finished floor for proper testing in accordance with MDC installation guidelines.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

N. Fill sprinkler system piping with water.

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

I. Welded Joints: Construct joints according to AWS D10.12M, using qualified processes and welding operators according to "Quality Assurance" article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

J. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

K. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

L. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.
3. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.7 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One (1) piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One (1) piece, cast brass with polished chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One (1) piece, cast brass with polished chrome-plated finish.
4. Bare Piping in Unfinished Service Spaces: One (1) piece, cast brass with polished chrome-plated finish clips.
5. Bare Piping in Equipment Rooms: One (1) piece, cast brass].
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:

1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2. Insulated Piping: Split plate, stamped steel with concealed hinge and spring clips.
3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
5. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish plate, stamped steel with exposed-rivet hinge and set-screw.
6. Bare Piping in Equipment Rooms: Split casting, cast brass.
7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.8 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Section 07 92 00.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Section 07 92 00.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized-steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe.

    a. Extend sleeves two (2) inches above finished floor level.
    b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level. Comply with requirements for flashing in Section 07 62 00.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:

    a. Galvanized-steel-pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.
    c. Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Interior Concrete Walls:

    a. Galvanized-steel-pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Section 07 84 13.

3.9 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.10 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run excess-pressure pumps.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 13 and 21 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 13 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 13 and 21 08 00 and manufacturer's written instructions/requirements.

3.13 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.15 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control vales, instead of specified fittings.

B. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one (1) of the following:

1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 6, shall be one (1) of the following:

1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.16 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Pendent, recessed, flush, and concealed sprinklers as indicated.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Pendent, dry sprinklers, Sidewall, dry sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
4. Upright Pendent and Sidewall Sprinklers: Factory white painted or other colors available on special order (consult factory for details) in finished spaces exposed to view; natural bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
5. Color and finishes to be selected by architect.

END OF SECTION

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Fire-department connections.
4. Sprinkler specialty pipe fittings.
5. Sprinklers.
6. Alarm devices.
7. Pressure gages.

B. Related Sections:

1. Section 211200 "Fire-Suppression Standpipes" for standpipe piping.
2. Section 211313 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.
3. Section 283111 "Digital, Addressable Fire-Alarm System" for alarm devices not specified in this Section.

1.2 SYSTEM DESCRIPTIONS

A. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open.

1.3 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:

a. As noted on the contract drawings

3. Maximum Protection Area per Sprinkler: Per UL listing.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For dry-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and professional engineer.

B. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

C. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

A. Standard Weight, Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Thinwall Galvanized-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

D. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

E. Galvanized, Steel Couplings: ASTM A 865, threaded.

F. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

G. Malleable- or Ductile-Iron Unions: UL 860.

H. Cast-Iron Flanges: ASME B16.1, Class 125.

I. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Anvil International, Inc.
b. Shurjoint Piping Products.

J. Grooved-Joint, Steel-Pipe Appurtenances:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Grinnell Mechanical Products, a TYCO International Company; Fig. 577 Rigid Couplings or comparable product by one of the following:

a. Anvil International, Inc.
b. Corcoran Piping System Co.
c. National Fittings, Inc.
d. Shurjoint Piping Products.
e. Victaulic Company.

2. Pressure Rating: [175 psig (1200 kPa)] [250 psig (1725 kPa)] [300 psig (2070 kPa)] minimum.
3. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flat-Face Flanges: Full-face gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating: 175 psig (1200 kPa).

B. Check Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide TYCO Fire Products LP; CV-1F or comparable product by one of the following:

   a. AFAC Inc.
   b. American Cast Iron Pipe Company; Waterous Company Subsidiary.
   c. Anvil International, Inc.
   d. Clow Valve Company; a division of McWane, Inc.
   e. Crane Co.; Crane Valve Group; Crane Valves.
   f. Crane Co.; Crane Valve Group; Jenkins Valves.
   g. Crane Co.; Crane Valve Group; Stockham Division.
   h. Fire-End & Croker Corporation.
   i. Fire Protection Products, Inc.
   j. Fivalco Inc.
   k. Globe Fire Sprinkler Corporation.
   l. Groeniger & Company.
   m. Kennedy Valve; a division of McWane, Inc.
   n. Matco-Norca.
   o. Metraflex, Inc.
   p. Milwaukee Valve Company.
   q. Mueller Co.; Water Products Division.
   r. NIBCO INC.
   s. Potter Roemer.
   t. Reliable Automatic Sprinkler Co., Inc.
   u. Shurjoint Piping Products.
   v. United Brass Works, Inc.
   w. Venus Fire Protection Ltd.
   x. Victaulic Company.
   y. Viking Corporation.
   z. Watts Water Technologies, Inc.

2. Standard: UL 312
3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Type: Swing check.
5. Body Material: Ductile iron.
6. End Connections: Flanged or grooved.

C. Bronze OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Stockham Division.
    c. Milwaukee Valve Company.
    d. NIBCO INC.
    e. United Brass Works, Inc.

2. Standard: UL 262.
3. Pressure Rating: 175 psig (1200 kPa).
4. Body Material: Bronze.
5. End Connections: Threaded.

D. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
    b. American Valve, Inc.
    c. Clow Valve Company; a division of McWane, Inc.
    d. Crane Co.; Crane Valve Group; Crane Valves.
    e. Crane Co.; Crane Valve Group; Jenkins Valves.
    f. Crane Co.; Crane Valve Group; Stockham Division.
    g. Hammond Valve.
    h. Milwaukee Valve Company.
    i. Mueller Co.; Water Products Division.
    j. NIBCO INC.
    k. Shurjoint Piping Products.
    l. United Brass Works, Inc.
    m. Watts Water Technologies, Inc.

2. Standard: UL 262.
3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

E. Indicating-Type Butterfly Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide TYCO Fire Products LP; BFV-N or comparable product by one of the following:

    a. Anvil International, Inc.
    b. Fivalco Inc.

c. Global Safety Products, Inc.
d. Kennedy Valve; a division of McWane, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Shurjoint Piping Products.
h. Victaulic Company.

2. Standard: UL 1091.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Valves NPS 2-1/2 (DN 65) and Larger:

a. Valve Type: Butterfly.
b. Body Material: Cast or ductile iron.
c. End Connections: Flanged, grooved, or wafer.

5. Valve Operation: Integral electrical, 115-V ac, prewired, two-circuit, supervisory switch indicating device.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Minimum Pressure Rating: 175 psig (1200 kPa).

B. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Affiliated Distributors.
b. Anvil International, Inc.
c. Barnett.
d. Conbraco Industries, Inc.; Apollo Valves.
e. Fire-End & Croker Corporation.
f. Fire Protection Products, Inc.
g. Flowserve.
h. FNW.
i. Jomar International, Ltd.
j. Kennedy Valve; a division of McWane, Inc.
k. Kitz Corporation.
l. Legend Valve.
m. Metso Automation USA Inc.
n. Milwaukee Valve Company.

o. NIBCO INC.
p. Potter Roemer.
q. Red-White Valve Corporation.
r. Southern Manufacturing Group.
s. Stewart, M. A. and Sons Ltd.
t. Victaulic Company.
u. Watts Water Technologies, Inc.

2.6 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Dry-Pipe Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide TYCO Fire Products LP; DPV-1 or comparable product by one of the following:

a. AFAC Inc.
b. Globe Fire Sprinkler Corporation.
c. Reliable Automatic Sprinkler Co., Inc.
d. Venus Fire Protection Ltd.
e. Victaulic Company.
f. Viking Corporation.

2. Standard: UL 260
3. Design: Differential-pressure type.
4. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
5. Air Compressor:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Gast Manufacturing Inc.
2) General Air Products, Inc,
3) Reliable Automatic Sprinkler Co., Inc.
4) Viking Corporation.

b. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
c. Motor Horsepower: Fractional.
d. Power: 120-V ac, 60 Hz, single phase.

2.7 SPRINKLER SPECIALTY PIPE FITTINGS

A. General Requirements for Dry-Pipe-System Fittings: UL listed for dry-pipe service.

B. Branch Outlet Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Grinnell Mechanical Products, a Tyco International Company; Fig. 730 or comparable product by one of the following:

   a. Anvil International, Inc.
   b. National Fittings, Inc.
   c. Shurjoint Piping Products.
   d. Victaulic Company.

2. Standard: UL 213.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

C. Flow Detection and Test Assemblies:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; Model 513 or comparable product by one of the following:

   a. AGF Manufacturing Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Victaulic Company.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

D. Branch Line Testers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; F350 or comparable product by one of the following:

   a. Elkhart Brass Mfg. Company, Inc.
   b. Fire-End & Croker Corporation.
   c. Potter Roemer.

2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

E. Sprinkler Inspector's Test Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; F350 or comparable product by one of the following:

   a. AGF Manufacturing Inc.
   b. Triple R Specialty.
   c. Victaulic Company.
   d. Viking Corporation.

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

F. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. CECA, LLC.
   b. Corcoran Piping System Co.
   c. Merit Manufacturing; a division of Anvil International, Inc.

2. Standard: UL 1474.
3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Body Material: Steel pipe with EPDM O-ring seals.

5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

G. Flexible, Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Fivalco Inc.
   b. FlexHead Industries, Inc.
   c. Gateway Tubing, Inc.

2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175 psig (1200 kPa) minimum.
5. Size: Same as connected piping, for sprinkler.

2.8 SPRINKLERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; DS-1, DS-3, DS-C, DS-ECC, DS-2 or comparable product by one of the following:

1. AFAC Inc.
2. Globe Fire Sprinkler Corporation.
3. Reliable Automatic Sprinkler Co., Inc.
4. Venus Fire Protection Ltd.
5. Victaulic Company.
6. Viking Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
3. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
4. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.

2. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with discharge coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes:

1. Chrome plated.
2. Bronze.
3. Painted.

E. Special Coatings:

1. Wax.
2. Lead.
3. Corrosion-resistant paint.

F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

G. Sprinkler Guards:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; G1, G4, G1/S1, G2, WS-2, WSG-2, G5 or comparable product by one of the following:

a. Reliable Automatic Sprinkler Co., Inc.
b. Victaulic Company.
c. Viking Corporation.

2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.9 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tyco Fire Products LP; WMA-1 or comparable product by one of the following:

a. Globe Fire Sprinkler Corporation.
b. Victaulic Company.

c. Viking Corporation.

2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 8 1/2-inch (216-mm) diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: NPS 1 (DN 25) drain connection.

C. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Fire-Lite Alarms; a Honeywell company.
b. Kennedy Valve; a division of McWane, Inc.
c. Potter Electric Signal Company.
d. System Sensor; a Honeywell company.

2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.10 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AMETEK, Inc.; U.S. Gauge Division.
2. Ashcroft, Inc.
3. Brecco Corporation.
4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

F. Air System Piping Gage: Include "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements in Section 221116 "Domestic Water Piping" for interior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 13 for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

N. Drain dry-pipe sprinkler piping.

O. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices and air compressors.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

a. Install air compressor and compressed-air supply piping.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and as indicated on the Architectural Reflected ceiling plans

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.7 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire-department connections.

B. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

3.8 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.11 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded, or grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. Sprinkler specialty fittings may be used, downstream of control vales, instead of specified fittings.

C. Dry-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with plain ends; plain-end-pipe fittings; and twist-locked joints.
3. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Dry-pipe sprinkler system, NPS 2-1/2 to NPS 6 (DN 65 to DN 150, shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.12 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Dry pendent, recessed, flush, and concealed sprinklers, as indicated.
3. Wall Mounting: Dry sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, dry pendent sprinklers; and dry sidewall sprinklers as indicated.
5. Special Applications: Extended-coverage and quick-response sprinklers where indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
4. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Provide a pre-engineered total flooding fire suppression system with automatic detection and control

B. Section Includes:

1. Piping and piping specialties.

2. Extinguishing-agent containers.

3. Extinguishing agent.

4. Detection and alarm devices.

5. Control and alarm panels.

6. Accessories.

7. Connection devices for and wiring between system components.

8. Connection devices for power and integration into building's fire-alarm system.

C. Section Excludes:

1. Power supply (120/240 VAC) to system control panel.

2. Interface (conduit and wiring) to HVAC units, dampers, electric power supplies, relays, or shunt-trip breakers.

3. Interface (conduit and wiring) to local/remote fire alarm system

4. Connection to listed central station fire alarm system.

5. Room sealing, other than penetrations made by the suppression system contractor during system installation. Suppression system contractor shall

coordinate room sealing requirements with project's General contractor and all sub-contractors.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. AHJ: Authority Having Jurisdiction.

C. EPO: Emergency Power Off.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that clean agents comply.

C. Shop Drawings: For clean-agent fire-extinguishing system signed and sealed by a qualified professional engineer.

1. Prepared by persons with the following qualifications:

a. Trained and certified by the manufacturer of the Clean Agent Suppression system.
b. NICET certified Fire-Alarm Technician, Level III minimum.

2. Comply with recommendations in the "Working Plans" Section of the "System Design" Chapter in NFPA 2001.
3. Comply with the recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
4. Include plans, elevations, sections, details, and attachments to other work.
5. Include design calculations: Enclosure volume, agent quantity, backup battery, voltage drop, detector spacing, etc.
6. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
7. Specifier Note: Retain subparagraph below for projects where routing of cable and conduit is critical.
8. Include plans to indicate mounting location of field devices, including size and routing of cable and conduits.
9. Specifier Note: Retain subparagraph below if submittals are required to be sealed by a PE.

10. Submittals shall be signed and sealed by a qualified professional engineer prior to submitting them to the Authority Having Jurisdiction.
11. Specifier Note: Retain subparagraph below if a construction permit is required prior to commencing the Work of this Section.
12. Submittals shall be approved by the Authority Having Jurisdiction prior to submitting them to Architect.

D. Delegated-Design Submittal: For clean-agent fire-extinguishing system signed and sealed by the qualified professional engineer.

1. Indicate compliance with performance requirements and design criteria, including analysis data.

2. Include design calculations for weight, volume, and concentration of extinguishing agent required for each hazard area.

3. Indicate the Following on Reflected Ceiling Plans:

   a. Ceiling penetrations and ceiling-mounted items.
   b. Extinguishing-agent containers if mounted above floor, piping and discharge nozzles, detectors, and accessories.
   c. Method of attaching hangers to building structure.
   d. Other ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, and access panels.

4. Indicate the Following on Occupied Work Area Plans:

   a. Controls and alarms.
   b. Extinguishing-agent containers, piping and discharge nozzles if mounted in space, detectors, and accessories.
   c. Equipment and furnishings.

5. Indicate the Following on Access Floor Space Plans:

   a. Extinguishing-agent containers, piping and discharge nozzles, detectors, and accessories.
   b. Method of supporting piping.

6. Indicate the Following on Ceiling Plans:

   a. Extinguishing-agent containers, piping and discharge nozzles, detectors, and accessories.
   b. Method of supporting piping.
   c. Other equipment located in the ceiling space that is being protected including sprinkler piping, HVAC equipment, raceways, or conduit.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Domestic water piping.

2. Items Penetrating Finished Ceiling Include the Following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.

B. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.

C. Seismic Qualification Certificates: For extinguishing-agent containers and control panels from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

E. Installer Qualifications:

1. Authorized distributor of the system manufacturer. Shall maintain an inventory of replacement parts.
2. Trained by the system manufacturer to design, install, test, and maintain the clean agent extinguishing system.
3. Provide proof of emergency service available on a twenty-four hour, seven-days-a-week basis.
4. Maintain or have access to a recharging station capable of recharging the largest suppression system within 72 hours after a discharge.
5. Minimum five (5) years' experience in the design, installation, and testing of clean-agent fire extinguishing systems. A list of systems of similar nature and scope shall be provided upon request.
6. Shall employ a NICET Level III certified special hazard designer, who will be responsible for this project.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For special agent system to include in emergency, operation, and maintenance manuals.

B. Deliver copies to Authorities Having Jurisdiction and include the following:

1. Comply with the “Records” Section of the “Inspections, Testing and Maintenance” Chapter of NFPA 72.
2. Provide “Record of Completion Documents” according to NFPA 72 article “Permanent Records” in the “Records” section of the “Inspection, Testing and Maintenance” Chapter in NFPA 72.
3. Record copy of site-specific software.
4. Provide “Maintenance, Inspection and Testing Records” according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer’s user training manuals.

5. Manufacturer’s required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at the control panel.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.

1. Detection Devices: Not less than 20 percent of amount of each type installed.

2. Container Valves: Not less than 10 percent of amount of each size and type installed.

3. Nozzles: Not less than 20 percent of amount of each type installed.

4. Extinguishing Agent: Not less than 100 percent of amount installed in largest hazard area. Include pressure-rated containers with valves.

1.8 QUALITY ASSURANCE

A. The installing contractor shall be trained by the suppression system hardware manufacturer to design, install, test, and maintain the fire suppression systems and shall submit a copy of a current and valid Certificate of Training issued by the

suppression system manufacturer to the system Owner, the Architect/Engineer and all authorizes having jurisdiction before commencing installation.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. FM Global Compliance: Provide components that are FM Approved and that are listed in FM Global's "Approval Guide."

D. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

E. All devices, components, and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended. The name of the manufacturer, part number, and serial number shall appear on all major components.

F. Locks for all cabinets shall be keyed alike.

PART 2 - PRODUCTS

2.1 CLEAN-AGENT SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide pre-engineered CPS NOVEC 1230 as manufactured by AMEREX Corporation or comparable product by one of the following:

1. Chemetron Fire Systems; a UTC Fire & Security company.
2. Fike Corporation.
3. Pem All Fire Extinguisher Corporation; a division of Pem Systems Inc.

B. Description: Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity above the ceiling and below the ceiling. System includes separate zones above and below the ceiling. If smoke is detected below the ceiling, extinguishing agent shall be discharged in zones above and below the ceiling. If smoke is detected above the ceiling, extinguishing agent shall be discharged in the zone above the ceiling only.

C. Delegated Design: Design clean-agent fire-extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, and C fires as appropriate for areas being protected, and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.

D. Performance Requirements: Performance requirements for HFC 227 per NFPA 2001.

E. Performance Requirements: Performance requirements for FK5 1 12 per NFPA 2001.

F. Performance Requirements: Performance requirements for IG 541 per NFPA 2001.

G. Performance Requirements: Performance requirements for NOVEC 1230 per NFPA 2001.

H. Cross-Zoned Detection: Devices located in two separate zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other zone.

I. Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.

J. System Operating Sequence:

1. Actuating First Detector: Visual indication on annunciator panel. Energize audible and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire-alarm system.

2. Actuating Second Detector: Visual indication on annunciator panel. Energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds (adj.), and discharge extinguishing agent.

3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.

K. System Operating Sequence: System shall be cross-zoned, air-sampling detectors and photoelectric detectors reporting to a fully programmable microprocessor-based control panel programmed to operate as follows:

1. If one photoelectric detector and air-sampling detector reaches the third detection level (Fire 1), agent discharge will be initiated as described for the third detection level (Fire 1) below.

2. Air-Sampling System:

a. First Detection Level (Alert): Mild audible and visual indication on annunciator panel. Strobe lights flash slowly in the protected area.
b. Second Detection Level (Action): Strong audible and visual indication on annunciator panel. Strobe lights flash rapidly in the protected area.
c. Third Detection Level (Fire 1): Strong audible and visual indication on annunciator panel. Energize horn(s), bell(s), and strobe light(s) in the protected area and outside entry doors. Shut down air-conditioning and

ventilating systems serving the protected area, and close doors in the protected area. Send signal to fire-alarm system, initiate 30-second time delay for extinguishing-agent discharge, and discharge extinguishing agent. At agent discharge, terminate power to equipment in the protected area.

d. Fourth Detection Level (Fire 2): Same as Fire 1.

L. Manual stations shall immediately discharge extinguishing agent when activated.

M. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.

N. EPO: Will terminate power to protected equipment immediately on actuation.

O. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.

P. Power Transfer Switch: Transfer from normal to stand-by power source.

Q. Seismic Performance: Fire-suppression piping and containers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 PIPING MATERIALS

A. See "Writing Guide" Article in the Evaluations for a discussion on the Section Text's organization and the most efficient way to revise the Section Text. See "Manufacturer's Installation Manual" Article for applications of pipe, tube, fitting, and joining materials.

B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

2.3 PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106/A 106M, Grade A and Grade B; Schedule 40, Schedule 80, and Schedule 160, seamless steel pipe.

1. Threaded Fittings:

a. Malleable-Iron Fittings: ASME B16.3, Class 300.
b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.

c. Fittings Working Pressure: 620 psig (4278 kPa) minimum.
d. Flanged Joints: Class 300 minimum.

2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.

3. Steel, Grooved-End Fittings: FM Approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.4 VALVES

A. General Valve Requirements:

1. UL listed or FM Approved for use in fire-protection systems.

2. Compatible with type of clean agent used.

B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.

D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.5 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.

1. Finish: Red, enamel or epoxy paint.

2. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.

3. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.

4. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.6 FIRE-EXTINGUISHING CLEAN AGENT

A. CPS NOVEC 1230 Clean Agent:

1. Basis-of-Design Product: Subject to compliance with requirements, provide AMEREX CPS pre-engineered system w/ NOVEC 1230 or comparable product by one of the following:

a. DuPont.
b. Great Lakes Chemical Corporation; a Chemtura company.

2.7 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, size, discharge pattern, and capacity required for application.

2.8 MANIFOLD AND ORIFICE UNIONS

A. Description: NRTL-listed device with minimum 2175-psig (15-MPa) pressure rating, to control flow and reduce pressure of IG-541 gas in piping.

1. NPS 2 (DN 50) and Smaller: Piping assembly with orifice, sized for system design requirements.

2. NPS 2-1/2 (DN 65) and Larger: Piping assembly with nipple, sized for system design requirements.

2.9 CONTROL PANELS

A. Description: FM Approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.

1. Mounting: Recessed flush with surface.

D. Supervised Circuits: Separate circuits for each independent hazard area.

1. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.

2. Manual pull-station circuit.

3. Alarm circuit.

4. Release circuit.

5. Abort circuit.

6. EPO circuit.

E. Control-Panel Features:

1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.

2. Automatic switchover to standby power at loss of primary power.

3. Storage container, low-pressure indicator.

4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Annunciator Panel: Graphic type showing protected, hazard-area plans, as well as locations of detectors and abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless-steel or aluminum enclosure.

G. Standby Power: Sealed lead calcium or Sealed, valve-regulated, recombinant lead acid batteries with capacity to operate system for 24 hours and alarm for minimum of 15 minutes. Include automatic battery charger that has a varying charging rate between trickle and high depending on battery voltage, and that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, automatic transfer switch, and suitable enclosure.

2.10 DETECTION DEVICES

A. General Requirements for Detection Devices:

1. Comply with NFPA 2001, NFPA 72, and UL 268.

2. 24-V dc, nominal.

B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.

D. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.

1. Pipe Network: CPVC tubing connects control unit with calibrated sampling holes.

2. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.

3. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg (12.5 Pa) at all sampling ports.

4. Control Unit: Multizone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.

E. Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.

2.11 MANUAL STATIONS

A. General Description: Semi-recessed FM Approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.12 SWITCHES

A. Description: FM Approved or NRTL listed, where available, **120-V** ac or low voltage compatible with controls. Include contacts for connection to control panel.

1. Low-Agent Pressure Switches: Pneumatic operation.

2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.

3. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.13 ALARM DEVICES

A. Description: Listed and labeled by an NRTL or FM Approved, low voltage, and surface mounting. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" or Section 283112 "Zoned (DC Loop) Fire-Alarm System" for alarm and monitoring devices.

B. Bells: Minimum 6-inch (150-mm) diameter.

C. Horns: 90 to 94 dBA.

D. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with hazard-area leakage requirements, installation tolerances, and other conditions affecting work performance.

1. The general contractor shall be responsible for sealing and securing the protected enclosure against agent loss and/or leakage during the required agent “hold’ period.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Clean agent PIPING APPLICATIONS

A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.

B. NPS 2 (DN 50) and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.

C. NPS 2-1/2 (DN 65) and Larger: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.

D. Piping between Storage Containers and Orifice Union: Schedule 80, steel pipe; forged-steel welding fittings; and welded joints.

3.3 CLEAN-AGENT PIPING INSTALLATION

A. Install clean-agent extinguishing piping and other components level and plumb, according to manufacturers' written instructions.

B. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.

C. Install extinguishing-agent containers anchored to substrate.

D. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution."

1. Install valves designed to prevent entrapment of liquid, or install pressure relief devices in valved sections of piping systems.

2. Support piping using supports and methods according to NFPA 13.

3. Install seismic restraints for extinguishing-agent containers and piping systems.

4. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

3.4 DETECTION, ACTUATION, ALARM, AND CONTROL SYSTEMS INSTALLATION

A. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 72 and NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

B. Smoke or Heat Detector Spacing:

1. Comply with NFPA 72, “Smoke-Sensing Fire Detectors” Section in the “Initiating Devices” Chapter, for smoke detector spacing.
2. Comply with NFPA 72, “Heat-Sensing Fire Detectors” Section in the “Initiating Devices” Chapter, for heat detector spacing.

3. Specifier Note: Retain first subparagraph below to indicate how Contractor shall determine detector spacing.
4. Smoke ceiling spacing shall not exceed 30 feet (9 m).
5. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
6. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
7. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

C. Audible Alarm-Indicating Devices: Wall mounted with tops above the finished floor not less than 90 inches (2.29 m), and below the ceiling not less than 6 in. (150 mm). Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

D. Visible Alarm-Indicating Devices: Wall mounted with entire lends not less than 80 in. (2.03 m) and not greater than 96 in. (2.44 m) above the finished floor. Where ceiling height does not permit mounting at minimum height, mount within 6 inches (150 mm) of the ceiling.

E. Combination Audible-Visual Devices: Where combination audible and visual devices are used, mount devices according to Visual Alarm-Initiating Device requirements.

F. Control Unit: Flush mount, with top of cabinet not more than 72 inches (1830 mm) above the finished floor.

G. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Connect electrical devices to control panel and to building's fire-alarm system. Electrical power, wiring, and devices are specified in Section 283111 "Digital, Addressable Fire-Alarm System" or Section 283112 "Zoned (DC Loop) Fire-Alarm System."

3.6 IDENTIFICATION

A. Identify system components and equipment. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.

C. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire-extinguishing system.

D. Install signs at entry doors to advise persons outside the room the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

3.7 SYSTEM WIRING

A. Wiring shall be installed by qualified individuals, in a neat and workmanlike manner in accordance with the National Electrical Code (NEC), Article 725 and 760, except as otherwise permitted for limited energy circuits as described in NFPA 72. Installation shall meet all local, state, province and/or country codes.

B. All wiring shall be installed in electrical metallic tubing (EMT) or conduit, and must be kept separate from all other building wiring. Runs of conduit shall be straight, neatly arranged, properly supported and installed parallel and perpendicular to walls and partitions.

C. Conductors shall be sized according to the design documents and color coded to allow easy circuit identification.

D. All wires shall be tagged at all junction boxes.

E. All wires shall be tested for the presence of opens, shorts and grounds prior to connection to control panel. Final wire terminations to control panel shall be made under the direct supervision of a factory trained representative.

F. All system components shall be securely supported independent of the wiring.

G. Ground control panel and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to control panel.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Submit test plan for review and approval by the owner or owner’s designated representative prior to performing tests.

C. Detection, Actuation, Alarm, and Control Systems Tests:

1. Visual Inspection: Conduct the visual inspection prior to testing.

    a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in it "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamental of Fire Alarm Systems" Chapter.
    b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in FNPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. Operational Test: After electrical circuitry has been energized, apply power to control panel and confirm proper unit operation. Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing, and Maintenance" Chapter in NFPA 72.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Clean-Agent Fire Extinguishing Systems Test:

1. Flow Test: Using nitrogen or other inert gas, perform a flow test on the piping network to verify that flow is continuous and unobstructed through piping and nozzles.
2. Pressure/Leak Test: pneumatically test the piping in a closed circuit for a period of 10 minutes at 40 psi (276 kPa). At the end of 10 minutes, the pressure drop shall not exceed 20 percent of the test pressure. Repair leaks and retest until no leaks exist.
3. Room Pressurization Test: After all construction work is complete, conduct a room pressurization test in accordance with NFPA 2001 in each clean agent suppression system hazard area. Test shall confirm enclosures ability to retain the agent concentration level for the required hold time. If the test fails, the suppression system contractor shall coordinate room sealing with the general contractor. Additional tests shall be conducted until successful test results are achieved. Include final test results in project 'Closeout Submittals'.

E. System will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports: Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

3.9 CLEANING

A. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.

3.10 SYSTEM FILLING

A. Preparation:

1. Verify that piping system installation is completed and cleaned.

2. Check for complete enclosure integrity.

3. Check operation of ventilation and exhaust systems.

B. Filling Procedures:

1. Fill extinguishing-agent containers with extinguishing agent, and pressurize to indicated charging pressure.

2. Install filled extinguishing-agent containers.

3. Energize circuits.

4. Adjust operating controls.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain clean-agent fire-extinguishing systems.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Piping materials and installation instructions common to most piping systems.

B. Transition fittings.

C. Dielectric fittings.

D. Mechanical sleeve seals.

E. Sleeves.

F. Escutcheons.

G. Grout.

H. Equipment installation requirements common to equipment sections.

I. Painting and finishing.

J. Concrete bases.

K. Supports and anchorages.

1.3 RELATED REQUIREMENTS

A. Section 01 91 13 - General Commissioning Requirements.

B. Section 22 08 00 - Commissioning of Plumbing.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 TRANSITION FITTINGS

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.
c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.

f. Viking Johnson.

B. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Fernco, Inc.
c. Mission Rubber Company.
d. Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 degrees F.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.

1. Manufacturers:

    a. Calpico, Inc.
    b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F.

1. Manufacturers:

    a. Perfection Corp.
    b. Precision Plumbing Products, Inc.
    c. Sioux Chief Manufacturing Co., Inc.
    d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Metraflex Co.
    d. Pipeline Seal and Insulator, Inc.
    e. Pro-Set.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. Refer to individual specification sections for types and materials.

2.9 GROUT

A. Description: ASTM C1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    c. Insulated Piping: One-piece, stamped-steel type with spring clips.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.

h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes, except for holes located in the floors of mechanical equipment rooms.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level. Refer to Section 07 62 00 for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than six (6) inches in diameter.
2. Install cast-iron "wall pipes" for sleeves six (6) inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 13 for materials.

T. Verify final equipment locations for roughing-in.

U. Refer to equipment specifications in other sections of these specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Section 09 91 00.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at project.

1. Construct concrete bases of dimensions indicated, but not less than four (4) inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 50 00 for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 13 and 22 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 13 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 13 and 22 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. General requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this section except when stricter requirements are specified in plumbing equipment schedules or sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degrees C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multi-speed Motors: Variable torque.
1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multi-speed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multi-speed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Flexible-hose packless expansion joints.

B. Metal-bellows packless expansion joints.

C. Rubber packless expansion joints.

D. Grooved-joint expansion joints.

E. Pipe loops and swing connections.

F. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.

2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

D. Welding certificates.

E. Product Certificates: For each type of expansion joint, from manufacturer.

F. Maintenance Data: For expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.

B. Products are required to comply with NSF/ANSI 61: Drinking Water System Components – Health Effects.

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Flex Pression Ltd.
d. Metraflex, Inc.
e. Unisource Manufacturing, Inc.
2. Description: Manufactured assembly with inlet and outlet elbow fittings and two (2) flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 degrees F and 340 psig at 450 degrees F ratings.

b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 degrees F and 500 psig at 450 degrees F ratings.

6. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.
   a. Stainless steel hoses and single-braid, stainless steel sheaths with 300 psig at 70 degrees F and 225 psig at 450 degrees F ratings.
   b. Stainless steel hoses and double-braid, stainless steel sheaths with 420 psig at 70 degrees F and 315 psig at 450 degrees F ratings.
7. Expansion Joints for Steel Piping NPS 2 and Smaller: Stainless steel fittings with threaded end connections.
   a. Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 degrees F and 325 psig at 600 degrees F ratings.
   b. Stainless steel hoses and double-braid, stainless steel sheaths with 700 psig at 70 degrees F and 515 psig at 600 degrees F ratings.
8. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Stainless steel fittings with flanged end connections.
   a. Stainless steel hoses and single-braid, stainless steel sheaths with 200 psig at 70 degrees F and 145 psig at 600 degrees F ratings.
   b. Stainless steel hoses and double-braid, stainless steel sheaths with 275 psig at 70 degrees F and 200 psig at 600 degrees F ratings.
9. Expansion Joints for Steel Piping NPS 8 to NPS 12: Stainless steel fittings with flanged end connections.
   a. Stainless steel hoses and single-braid, stainless steel sheaths with 125 psig at 70 degrees F and 90 psig at 600 degrees F ratings.
   b. Stainless steel hoses and double-braid, stainless steel sheaths with 165 psig at 70 degrees F and 120 psig at 600 degrees F ratings.

B. Metal-Bellows Packless Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers:
   a. American BOA, Inc.
   b. Badger Industries, Inc.
   c. Flex-Hose Co., Inc.
   d. Flexicraft Industries.
   e. Flex Pression Ltd.
   f. Flex-Weld, Inc.
   g. Flo Fab Inc.
   h. Metraflex, Inc.
   i. Unaflex.
   j. U.S. Bellows, Inc.
2. Standards: ASTM F1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 175 psig unless otherwise indicated.
5. Configuration: Single joint with base class(es) unless otherwise indicated.
6. Expansion Joints for Copper Tubing: Single- or multi phosphor-bronze

bellows, copper pipe ends, and brass shrouds.
a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint or threaded.
c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

C. Rubber Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Amber/Booth Company, Inc.; a div. of Vibration Isolation Products of Texas, Inc.
   b. Flex-Hose Co., Inc.
   c. Flexicraft Industries.
   d. Flex-Weld, Inc.
   e. Garlock Sealing Technologies.
   f. General Rubber Corporation.
   g. Mason Industries, Inc.; Mercer Rubber Co.
   h. Metraflex, Inc.
   i. Proco Products, Inc.
   j. Red Valve Company, Inc.
   k. Tozen Corporation.
   l. Unaflex.
   m. Unisource Manufacturing, Inc.

3. Standards: ASTM F1123 and FSA's "Technical Handbook:Non-Metallic Expansion Joints and Flexible Pipe Connectors."
4. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.
5. Arch Type: Single or multiple arches with external control rods.
6. Spherical Type: Single or multiple spheres with external control rods.
7. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: 150 psig at 220 degrees F.
8. Minimum Pressure Rating for NPS 5 and NPS 6: 140 psig at 200 degrees F.
9. Minimum Pressure Rating for NPS 8 to NPS 12: 140 psig at 180 degrees F.
10. Material for Fluids Containing Acids, Alkalis, or Chemicals: EPDM.
11. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N.
12. Material for Water: Buna-N.
13. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.2 GROOVED-JOINT EXPANSION JOINTS

A. Basis-of-Design Product: Subject to compliance with requirements, provide or comparable product by one (1) of the following:

1. Anvil International, Inc.
2. Shurjoint Piping Products.
3. Victaulic Company.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A53, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Five (5) flexible type for steel-pipe dimensions. Include ferrous housing sections, EPDM gasket suitable for cold and hot water, and bolts and nuts.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers:
   a. Adsco Manufacturing LLC.
   b. Advanced Thermal Systems, Inc.
   c. Flex-Hose Co., Inc.
   d. Flexicraft Industries.
   e. Flex-Weld, Inc.
   f. Hyspan Precision Products, Inc.
   g. Metraflex, Inc.
   h. Senior Flexonics Pathway.
   i. Unisource Manufacturing, Inc.
   j. U.S. Bellows, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A36.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. Stud: Threaded, zinc-coated carbon steel.
   b. Expansion Plug: Zinc-coated steel.
   c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with

hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
c. Washer and Nut: Zinc-coated Steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

C. Install rubber packless expansion joints according to FSA-NMEJ-702.

D. Install grooved-joint expansion joints to grooved-end steel piping

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five (5) pipe fittings including tee in main.

C. Connect risers and branch connections to terminal units with at least four (4) pipe fittings including tee in riser.

D. Connect mains and branch connections to terminal units with at least four (4) pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
B. Install one (1) guide(s) on each side of pipe expansion fittings and loops. Install

guides nearest to expansion joint not more than four (4) pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:
   1. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
   3. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use
      MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Bimetallic-actuated thermometers.

B. Filled-system thermometers.

C. Liquid-in-glass thermometers.

D. Thermowells.

E. Dial-type pressure gages.

F. Gage attachments.

G. Test plugs.

H. Test-plug kits.

I. Sight flow indicators.

1.3 RELATED SECTIONS

A. Division 21 fire-suppression piping sections for fire-protection pressure gages.

B. Section 22 11 16 - Domestic Water Piping: Water meters inside the building.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Product Certificates: For each type of meter and gage, from manufacturer.

D. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Trerice, H. O. Co.

B. Standard: ASME B40.200.

C. Case: sealed type(s); stainless steel with 5-inch nominal diameter.

D. Dial: Non-reflective aluminum with permanently etched scale markings and scales in degrees F.

E. Connector Type(s): Union joint, adjustable angle and rigid, bottom, with unified-inch screw threads.

F. Connector Size: 1/2-inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375-inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus one (1) percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ashcroft Inc.
   b. Ernst Flow Industries.
   c. Marsh Bellofram.
   d. Trerice, H. O. Co.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel 5-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one (1) percent of scale range.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ashcroft Inc.
   b. Ernst Flow Industries.
   c. Marsh Bellofram.
   d. Trerice, H. O. Co.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.

7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Brass.
11. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ashcroft Inc.
   b. Ernst Flow Industries.
   c. Marsh Bellofram.
   d. Trerice, H. O. Co

2. Standard: ASME B40.100.
3. Case: Sealed type; metal 6-inch nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Trerice, H. O. Co.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 degrees F].

F. Core Inserts: EPDM self-sealing rubber.

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Trerice, H. O. Co.

B. Furnish one (1) test-plug kit(s) containing two (2) thermometer(s), one (1) pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 degrees F.

D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 degrees F.

E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.

F. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install test plugs in piping tees.

K. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each mixing valves.
3. Hot water circulating lines at pump.

L. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal -case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Test plug with EPDM self-sealing rubber inserts.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 150 degrees F.

B. Scale Range for Domestic Hot-Water Piping: 0 to 250 degrees F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at suction and discharge of each domestic water pump shall be one (1) of the following:

1. Sealed Solid-front, pressure-relief direct-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 100 psi.

B. Scale Range for Domestic Water Piping: 0 to 200 psi

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Bronze angle valves.

B. Bronze ball valves.

C. Iron, grooved-end butterfly valves.

D. Bronze lift check valves.

E. Bronze swing check valves.

F. Iron swing check valves.

G. Iron, grooved-end swing check valves.

H. Bronze gate valves.

I. Iron gate valves.

J. Bronze globe valves.

K. Lubricated plug valves.

L. Chainwheels.

1.3 RELATED SECTIONS

1. Division 22 plumbing piping sections for specialty valves applicable to those Sections only.
2. Section 22 05 53 - Identification for Plumbing Piping and Equipment: Valve tags and schedules.
3. Division 33 water distribution piping sections for general-duty and specialty valves for site construction piping.

1.4 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Non-rising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of valve indicated.

1.6 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service and NSF/ANSI 372 for low lead content.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every five (5) plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. NIBCO INC.
   b. Milwaukee Valve Company.
   c. Watts

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. American Valve, Inc.
   b. NIBCO INC.
   c. Watts.

2.3 BRONZE BALL VALVES

A. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One (1) piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) pieces.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

2.4 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. NIBCO INC.
b. Watts.
c. Victaulic Company.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 175 psig.
c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM.

2.5 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: NBR, PTFE, or TFE.

2.6 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

C. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Spence Strainers International; a division of CIRCOR International, Inc.
   i. Sure Flow Equipment Inc.
   j. Val-Matic Valve & Manufacturing Corp.

2. Description:

   a. Standard: MSS SP-125.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A126, gray iron.
   d. Style: Compact wafer.
   e. Seat: EPDM.

2.7 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. American Valve, Inc.
   b. NIBCO INC.
   c. Watts.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.

h. Handwheel: Malleable iron.

B. Class 125, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. American Valve, Inc.
   b. NIBCO INC.
   c. Watts.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. American Valve, Inc.
   b. NIBCO INC.
   c. Watts.

4. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American Valve, Inc.
    b. NIBCO INC.
    c. Watts.

2. Description:

    a. Standard: MSS SP-70, Type I.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A126, gray iron with bolted bonnet.
    d. Ends: Flanged.
    e. Trim: Bronze.
    f. Disc: Solid wedge.
    g. Packing and Gasket: Asbestos free.

2.8 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American Valve, Inc.
    b. NIBCO INC.
    c. Watts.

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded or solder joint.
    e. Stem and Disc: Bronze.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron.

B. Class 125, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. Crane Co.; Crane Valve Group; Stockham Division.

b. NIBCO INC.
c. Red-White Valve Corporation.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.9 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-78, Type II.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short.
e. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-78, Type II.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short.
e. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-78, Type IV.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short.
e. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. NIBCO INC.
c. Watts.

2. Description:

a. Standard: MSS SP-78, Type IV.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short.
e. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly & gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service: Globe valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Grooved ends.
3. For Copper Tubing, NPS 5 and Larger: Grooved ends
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125 disc.
3. Ball Valves: One (1) piece, full port, bronze with bronze trim.
4. Bronze Swing Check Valves: Class 125 bronze disc.
5. Bronze Gate Valves: Class 125 RS.
6. Bronze Globe Valves: Class 125 bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves: Class 150.
3. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves: 175 CWP.
5. Iron Swing Check Valves: Class 125 seats.
6. Iron Swing Check Valves with Closure Control: Class 125, lever and spring weight.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Metal pipe hangers and supports.

B. Trapeze pipe hangers.

C. Metal framing systems.

D. Thermal-hanger shield inserts.

E. Fastener systems.

F. Pipe stands.

G. Pipe positioning systems.

H. Equipment supports.

1.3 RELATED SECTIONS

A. Section 05 50 00 - Metal Fabrications: Structural steel shapes and plates for trapeze hangers for pipe and equipment supports.

B. Division 21 fire-suppression piping sections for pipe hangers for fire-suppression piping.

C. Section 22 05 16 - Expansion Fittings and Loops for Plumbing Piping: Pipe guides and anchors.

D. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Piping and Equipment: Vibration isolation devices.

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include product data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

E. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.

b. Cooper B-Line, Inc.
c. Thomas & Betts Corporation.
d. Unistrut Corporation; Tyco International, Ltd.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Hot-dipped galvanized.
8. Paint Coating: Epoxy.
9. Plastic Coating: PVC Polyurethane.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.
c. Thomas & Betts Corporation.
d. Unistrut Corporation; Tyco International, Ltd.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Paint.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.
c. Thomas & Betts Corporation.
d. Unistrut Corporation; Tyco International, Ltd.

B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend two (2) inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece stainless steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two (2) or more cadmium-plated-steel or stainless steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless steel rod with plastic or stainless steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One (1) or more; plastic.
3. Vertical Members: Two (2) or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than four (4) inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 for curbs.

I. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 22 plumbing fixture sections for requirements for pipe positioning systems for plumbing fixtures.

J. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

K. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

L. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

M. Install lateral bracing with pipe hangers and supports to prevent swaying.

N. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

O. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

P. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

Q. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048-inch thick.

b. NPS 4: 12 inches long and 0.06-inch thick.

c. NPS 5 and NPS 6: 18 inches long and 0.06-inch thick.

d. NPS 8 to NPS 14: 24 inches long and 0.075-inch thick.

e. NPS 16 to NPS 24: 24 inches long and 0.105-inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Section 09 96 00.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 degrees F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two (2) rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 degrees F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 degrees F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one (1) of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one (1) support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two (2) vertical-type supports and one (1) trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Isolation pads.

B. Isolation mounts.

C. Restrained elastomeric isolation mounts.

D. Freestanding and restrained spring isolators.

E. Housed spring mounts.

F. Elastomeric hangers.

G. Spring hangers.

H. Spring hangers with vertical-limit stops.

I. Pipe riser resilient supports.

J. Resilient pipe guides.

K. Seismic snubbers.

L. Restraining braces and cables.

M. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC.

    a. Component Importance Factor:
    b. Component Response Modification Factor:
    c. Component Amplification Factor:

3. Design Spectral Response Acceleration at Short Periods (0.2 Second):
4. Design Spectral Response Acceleration at 1-Second Period:

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building

structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Preapproval and Evaluation Documentation: By an evaluation service member of an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Coordination Drawings: Show coordination of seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For professional engineer and testing agency.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded

element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

H. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of two (2) steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of two (2) steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.3 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Amber/Booth Company, Inc.
2. Cooper B-Line, Inc.; a division of Cooper Industries.
3. Hilti, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. TOLCO Incorporated; a brand of NIBCO INC.
7. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: ASTM A492 stainless steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select

anchor bolts with strength required for anchor and as tested according to ASTM E488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install seismic-restraint devices using methods approved by [an evaluation service member of an agency acceptable to authorities having jurisdiction] providing required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 11 16 for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least four (4) of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of sprint isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 PLUMBING VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. Furnish seismic restraint schedule as outlined below.

B. Supported or Suspended Equipment:

1. Equipment Location:
2. Pads:

    a. Material: Neoprene
    b. Thickness:
    c. Number of Pads:

3. Isolator Type:
4. Base Type:

5. Minimum Deflection:
6. Component Importance Factor:
7. Component Response Modification Factor:
8. Component Amplification Factor:

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Equipment labels.

B. Warning signs and labels.

C. Pipe labels.

D. Stencils.

E. Valve tags.

F. Warning tags.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Samples: For color, letter style, and graphic representation required for each identification material and device.

D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

E. Valve numbering scheme.

F. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Seton NamePlate
2. Kolbi
3. Emedco

B. Metal Labels for Equipment:

1. Material and Thickness: anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless steel rivets.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Red.
3. Background Color: Yellow.
4. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless steel rivets.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the specification section number and title where equipment is specified.

E. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the specification section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

2.6 CEILING MARKERS

A. All above ceiling devices to be labeled on ceiling grid with color coded identification as follows;

1. Plumbing valves and devices – GREEN 1" Diameter.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 09 91 00.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Domestic Water Piping:

   a. Background Color: Yellow.
   b. Letter Color: Blue.

2. Sanitary Waste and Storm Drainage Piping:

   a. Background Color: White.
   b. Letter Color: Blue.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Cold Water: Two (2) inches, round.
   b. Hot Water: Two (2) inches, round.

2. Valve-Tag Color:

   a. Cold Water: Green.
   b. Hot Water: Green.

3. Letter Color:

   a. Cold Water: White.
   b. Hot Water: Red.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS AND STANDARDS

1) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

B. In addition to work covered under this Section, comply with description of individual systems under other sections of the Specifications, but not limited to:

1) Section 10 28 13 - Toilet Accessories

2) Section 22 05 00 - Common Work Results for Plumbing

3) Section 22 11 16 - Domestic Water Piping

4) Section 22 13 16 - Sanitary Waste and Vent Piping

5) Section 22 14 13 - Facility Storm Drainage Piping

6) Section 22 42 00 – Commercial Plumbing Fixtures

1.2 WORK TO BE INSULATED

A. Domestic cold and hot water piping.

B. Hot water circulation piping.

C. Horizontal runs of leader piping.

D. Roof drain under surfaces and horizontal piping to leaders.

E. Under Handicapped Lavatories & Sinks - See Section 10 28 00

1.3 QUALITY ASSURANCE

A. Insulation shall be in accordance with the 2012 International Energy Conservation Code (IECC)

B. Composite installation of insulation material, jacket, facing, adhesive, and surface coating shall not exceed:

1) Flame spread - 25

2) Fuel contributed - 50

3) Smoke developed - 50

C. Test procedure for flame spread and smoke developed shall be in accordance with the following procedures:

1) ASTM E84

2) NFPA 255

3) UL 723

D. Accessories such as adhesives, mastics, cement, tapes, etc., shall have the same components rating as noted below.

E. Treatment of jackets or facings to impart flame and/or smoke compliance shall be permanent. The use of water-soluble treatment materials will not be allowed.

F. All products, or their shipping cartons, shall bear a label indicating that flame and smoke ratings do not exceed allowable limits.

G. Where a particular insulating material is specified for an individual system, i.e. water piping, insulate similarly all connections and accessories to the system.

H. The only exception to the above material requirements is where a material meeting these requirements is not available from any manufacturer; in which case, substitute items shall be subject to individual approval by the Architect.

1.4 QUALIFICATIONS OF INSTALLERS

A. Installers to be experienced specialists, with a minimum of three years in the trade, and shall be employed for installation of all insulation.

1.5 SUBMITTALS

A. General: Comply with the provisions of Section 01 33 00.

B. Product Data: After award of contract, submit:

1) Complete materials list of all items proposed to be furnished and installed under this section.

2) Manufacturers' recommended installation procedures which, when approved by the Architect, will become the basis for inspecting and accepting or rejecting actual installation procedures used on the Work.

1.6 PRODUCT HANDLING

A. Deliver materials to project site in manufacturer's original packaging containers.

B. Store materials off ground, protect against weather, condensation, and damage. At the end of each workday remove all damaged material from site.

C. Protection: use all means necessary to protect the materials of this section before, during, and after installation, and to protect the work and materials of all other trades.

D. Replacements: in the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect, and at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 ACCESSORY MATERIALS

A. Insulating and Finishing Cement: Calcium silicate, mineral fibers, binder

B. Surface Coating: Foster 30-36.

C. Vapor Barrier Adhesive: Foster 82-07.

D. Fire-resistive Adhesive: Foster 85-20.

E. Wire: Minimum 16 gage, copper clad soft annealed steel.

F. Vapor Barrier Tape: Flame-resistant coated cloth, pressure sensitive adhesive backing.

2.2 PIPE INSULATION

A. Pipe: Sectional one-piece premolded fibrous glass, factory applied flame retardant vapor barrier jacket with pressure sensitive tape sealing system:

1) Trade Name: Manville Micro-Lok with AT-P jacket.

2) Minimum Density: 3.5 PCF.

3) Maximum K-factor: 0.25 at 75^{o}F, mean.

B. Valves and Fittings: Premolded, fibrous glass fitting covers, or fabricated mitered segments of pipe insulation, finished with high impact, UV-resistant polyvinyl chloride covering. No staples, tacks or bands.

1) Trade Name: Zeston 2000.

2) Surface Finish:

a) Exposed: Uniform coat of surface coating.

b) Concealed: None required.

2.3 THICKNESS SCHEDULE

Piping System	Pipe Size	Thickness	Remarks
Cold Water	All	1"	Vapor Barrier
Hot Water	½" to 1"	1"	Vapor Barrier
	1-1/4" to 2"	1"	Vapor Barrier
	2-1/2" to 4"	1½"	Vapor Barrier
Hot water Circulation	1" max.	1"	Vapor Barrier
	1-1/4" to 2"	1"	Vapor Barrier
Hot Water Runouts	2" max.	1/2" min.	12' max. length
Leader Horizontals	All	1/2" min.	Vapor Barrier

2.4 ROOF DRAIN INSULATION

A. Roof drain under surfaces: shaped segments of fire retardant flexible foamed plastic sheet, applied with adhesive, joints sealed with adhesive. Trade names: FR/Armaflex.

1) Minimum Density: 6 PCF.

2) Maximum k-factor: 0.28 at 70 degrees F, mean.

B. Surface Finish: None required.

2.5 HANDICAPPED LAVATORIES AND SINKS

A. Insulation furnished under Section 10 28 00 and installed by this Contractor.

2.6 APPROVED MANUFACTURERS

A. Insulation:

1) Certain-Teed Corp., IG Group.

2) Johns-Manville.

3) Owens-Corning Fiberglass Corp.

4) Knauf Insulation Corp.

B. Fitting Covers:

1) Zeston Products, sub. Johns-Manville.

2) Ceel-Co.

3) Speedline Fittings Div., Horace T. Potts Co.

C. Accessory Materials:

1) Foster Div., - H.B. Fuller Co.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to installation of insulation, clean and dry the exterior surfaces of all pipes, fittings, and valves.

B. Note: Pipe and pipe fitting insulation cannot be installed until pressure tests on piping system have been completed and accepted.

3.2 INSTALLATION

A. Completely protect piping conveying water of temperature below 85 degrees F., against surface condensation with continuous completely sealed vapor barrier jacketed insulation.

B. Apply insulation to clean, dry, properly prepared surfaces of piping and equipment (tank) only after system has been tested satisfactorily.

C. Apply pipe insulation continuous through sleeves and hangers, and to piping in pipe spaces and concealed within building construction. Omit pipe insulation on chrome-plated piping, except at handicapped lavatories.

D. Use premoulded insulation shapes dimensionally compatible with outer configuration of pipe and fittings. Where standard shapes are unavailable fabricate or build up shapes from insulation materials having identical insulating qualities. Cut, score or miter insulation to fit surface shape.

E. Insulate valve bodies up to, and including bonnets; strainer bodies up to, but including blowout connections. Bevel ends of insulation adjacent to flanges to permit bolt removal.

F. Make allowances for expansion and contraction to avoid separation of insulation and surface finish.

G. Fill surface imperfections with insulation materials secured in place and finished off smoothly. Point up joints and breaks of block insulation with cement.

H. Apply surface finishes to entire insulated surface to present tight, smooth finish. Finish raw edges and ends neatly. Position outdoor jacket laps to shed water.

I. Paste down jacket laps and butt strips with fire resistive adhesive.

J. Use wire to secure insulation shapes and segments and outdoor jackets. Remove bands, when used, after jacket adhesives have set.

K. Use of staples is prohibited.

L. Remove damaged insulation and torn jackets, and replace with new. Seal minute jacket penetrations with surface coating.

3.3 PROTECTION OF INSULATION

A. Protect insulation on hot pipes by saddles from hangers, guides, rollers, and trapeze.

B. Do not use staples on vapor barrier jackets.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. Section 01 91 00 – General Commissioning Requirements

B. Division 22 – Plumbing

C. Division 23

D. Division 26

E. Division 28

1.3 REQUIREMENTS

A. The commissioning process requires the participation of Division 22 "Plumbing" to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 "Plumbing" shall fulfill commissioning responsibilities assigned to Division 22 in accordance with Section 01 91 00.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.

B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with Section 01 91 00.

C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. The intent of functional testing is to verify system operation is in accordance with design intent. Thorough test procedures will be utilized to verify systems and equipment through their full sequence of operations.

B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with Section 01 91 00.

C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 22 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

1. Water using systems

3.4 SAMPLE CHECKLISTS

A. See Attached.

Functional Test

DOMESTIC WATER HEATER

IMPORTANT:

Please refer to the Master Deficiency and Resolution Log for numbers referenced in parentheses, which will indicate deficiencies discovered and resolved. For quick reference you will find, in the front of this section a list of Master Deficiency and Resolution Log items pertaining only to this section.

1. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

2. Prerequisite Checklist

a. All associated equipment has been started up and is ready for functional testing.
b. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
c. Safeties and operating ranges reviewed.
d. Schedules and setpoints implemented.
e. This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
f. Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
g. Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	Domestic HW System
General Installation	
Permanent labels affixed	
Casing condition good: no dents	
Maintenance access acceptable for unit and components	
Concrete pad provided	
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)	
Clean up of equipment completed per contract documents	
Main gas, pilot gas pressure regulators, and high and low pressure switches are vented to the outdoors	
Water heater is ASME rated	
Piping arrangement installed per the contract documents	
Installation of combustion air fan and associated motorized damper	
Flue pipe installed as per the contract documents	
Valves and Piping	
Pipe fittings complete and pipes properly supported	
Pipes properly labeled	
Pipes properly insulated	
Relief valve on water heater properly piped	
Valves properly labeled	
Valves installed in proper direction	
Piping system properly flushed	
No leaking apparent around fittings	
Cold water make-up isolation valve	
Isolation valves installed per drawings	
Water heater drain valve	
ASME Pressure relief valve	
Re-circulation line connection to cold water make-up	
Gas connection with plug valve	
Gas train to water heater	
Sensors calibrated	

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	Domestic HW System
Electrical and Controls	
Power disconnects in place and labeled	
All electric connections tight	
Safeties in place and operable	
Misc.	
Aquastat installed on recirculation pumps	
Recirc pumps in place and service switches in place and labeled	

The checklist items of Part 3 are all successfully completed for given trade. ☐YES ☐NO

4. Functional Testing Record

Test #	**Mode ID**	**Test Procedure** (including special conditions)	**Expected Response**	**Pass Y/N**	**Note**
1	Operating control	Set operating controller above setpoints degrees F.	Burner turns on		
2	Operating control	Set operating controller below setpoints degrees F.	Burner turns off		
3	Combustion Fan Interlock	Simulate a need for the Water Heater to fire	Ensure that the Combustion Air fan is energized on and that the associated motorized damper operates as intended		
4	Recirc Pumps	Simulate a call for the domestic water heater	The circ pumps are interfaced with the BMCS for pump status and operate as needed. Ensure also that the disconnect switches associated will turn the pump on/off for service.		

The functional tests of Part 4 have all passed for given trade. ☐YES ☐NO

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Retain or delete this article in all sections of Project Manual.

1.2 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.3 SECTION INCLUDES

A. Pipes, tubes, and fittings.

B. Piping specialties.

C. Piping and tubing joining materials.

D. Valves.

E. Pressure regulators.

F. Mechanical sleeve seals.

G. Grout.

H. Concrete bases.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.5 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

C. Natural-Gas System Pressures within Buildings: Two (2) pressure ranges. Primary pressure is more than 0.5 psig but not more than two (2) psig, and is reduced to secondary pressure of 0.5 psig or less.

D. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.
6. Mechanical sleeve seals.
7. Escutcheons.

C. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4-inch per foot.
2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

D. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

E. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

F. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

G. Qualification Data: For qualified professional engineer.

H. Welding certificates.

I. Field quality-control reports.

J. Operation and Maintenance Data: For motorized gas valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70-2011, by a qualified testing agency, and marked for intended location and application.

D. Connecticut Liquefied Petroleum Gas and Liquefied Natural Gas Code and NFPA 30-2012 Flammable and Combustible Liquids Code.

E. National Fuel Gas Code NFPA 54-2012.

1.8 DELIVERY, STORAGE AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where project is located.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 08 31 00.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234 for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.
        3) Victualic Company.

    b. Steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Steel bolts, washers, and nuts.
    e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. Corrugated, Stainless Steel Tubing: Comply with ANSI/IAS LC 1.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. OmegaFlex, Inc.
    b. Parker Hannifin Corporation; Parflex Division.
    c. Titeflex.
    d. Tru-Flex Metal Hose Corp.

2. Tubing: ASTM A240, corrugated, Series 300 stainless steel.
3. Coating: PE with flame retardant.

    a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

        1) Flame-Spread Index: 25 or less.
        2) Smoke-Developed Index: 50 or less.

4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
5. Striker Plates: Steel, designed to protect tubing from penetrations.
6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.

7. Operating-Pressure Rating: Five (5) psig.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Corrugated stainless steel tubing with polymer coating.
4. Operating-Pressure Rating: 0.5 psig.
5. End Fittings: Zinc-coated steel.
6. Threaded Ends: Comply with ASME B1.20.1.
7. Maximum Length: 72 inches.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.

2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 degrees F complying with AWS A5.8. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Aboveground Manual Gas Shutoff Valve Schedule" articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves one (1) inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.

3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.
    f. Appollo.

2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Lee Brass Company.
    b. McDonald, A. Y. Mfg. Co.
    c. Val-Matic Valve and Manufacturing Corp.

2. Body: Bronze, complying with ASTM B584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.

6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Non-lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. McDonald, A. Y. Mfg. Co.
    b. Mueller Co.; Gas Products Div.
    c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78, Exterior Main Gas Shut-off.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following.

    a. Flowserve.
    b. Homestead Valve; a division of Olson Technologies, Inc.
    c. McDonald, A. Y. Mfg. Co.
    d. Milliken Valve Company.
    e. Mueller Co.; Gas Products Div.
    f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" articles.

7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.

H. Electrically Operated Valves: Comply with UL 429. (Laboratory Emergency Gas Shut-Off)

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. ASCO Power Technologies, LP; Division of Emerson.
   b. Eclipse Combustion, Inc.
   c. Isimet.
   d. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.
10. Gas solenoid enclosure, Isimet Series-S.
11. Key switch with pushbutton, LA Series Controller. 120v.
12. Mushroom type emergency off.120v.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Maxitrol
   b. American Meter Company.

c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
d. Invensys.
e. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.

C. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Actaris.
b. American Meter Company.
c. Eclipse Combustion, Inc.
d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
e. Invensys.
f. Maxitrol Company.
g. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.

9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: Five (5) psig.

2.6 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Hart Industries International, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
    f. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
    d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Advance Products & Systems, Inc.
    b. Calpico Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.7 SLEEVES

A. Steel Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.8 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Advance Products & Systems, Inc.
    b. Calpico Inc.
    c. Metraflex Company (The).
    d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.9 ESCUTCHEONS

A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Escutcheons: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Escutcheons: With set screw and chrome-plated finish.

F. Split-Plate, Stamped-Steel Escutcheons: With concealed hinge, set screw, and chrome-plated finish.

G. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.10 GROUT

A. Description: ASTM C1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.11 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of six (6) inches wide and four (4) mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 - 2012 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 - 2012 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 – 2012 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 31 20 00 for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than six (6) inches in diameter.
2. Install cast-iron "wall pipes" for sleeves six (6) inches and larger in diameter.

H. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

I. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

J. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 23 Section 05 19.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of two (2) percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons at penetrations of interior walls, ceilings, and floors.

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
d. Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
f. Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw or spring clips.
h. Piping in Equipment Rooms: One-piece, cast-brass type.
i. Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
j. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 07 84 13.

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of three (3) pipe diameters, but not less

than three (3) inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap with insect screen.

Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 23 05 19.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install emergency gas shut-off at exterior of building at meter location.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 23 05 48.

B. Comply with requirements for pipe hangers and supports specified in Section 23 05 29.

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8-inch.

2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8-inch.

3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8-inch.

4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2-inch.

5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8-inch.

3.8 CONNECTIONS

A. Connect to outlet side of gas meter according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 23 05 53 for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except six (6) inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Division 09 painting sections for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
c. Topcoat: Exterior alkyd enamel (gloss).
d. Color: Green.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior latex matching topcoat.
c. Topcoat: Interior latex (satin) (gloss).
d. Color: Green.

2. Alkyd System: MPI INT 5.1E.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior alkyd matching topcoat.
c. Topcoat: Interior alkyd .
d. Color: Green.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

E.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Use 3000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 03 30 00.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 - 2012 and authorities having jurisdiction.

2. Submit purge procedure to Office of State Fire Marshall for review and approval prior to performing work.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one (1) of the following:
1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping in accordance with 3.3, D.

B. Aboveground natural-gas piping shall be one (1) of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be one (1) of the following:

1. Corrugated stainless steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one (1) of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one (1) of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be one (1) of the following:

B.

1. Steel pipe with malleable-iron fittings and threaded joints.

C. Aboveground, distribution piping shall be one (1) of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with steel welding fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one (1) of the following:

1. Emergency gas shut off.

2. One-piece, bronze ball valve with bronze trim.
3. Two-piece, full-port, bronze ball valves with bronze trim.
4. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one (1) of the following:

1. Emergency gas shut off.

2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.
4. Cast-iron, non-lubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one (1) of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one (1) of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be one (1) of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building to 5'-0" outside of building.

B. Specialty valves.

C. Flexible connectors.

D. Escutcheons.

E. Sleeves and sleeve seals.

F. Wall penetration systems.

1.3 RELATED SECTIONS

A. Section 22 11 13 - Facility Water Distribution Piping: Water-service piping outside the building from source to the point where water-service piping enters the building.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7 - 2016.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following products:

1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.

4. Flexible connectors.
5. Backflow preventers and vacuum breakers.
6. Escutcheons.
7. Sleeves and sleeve seals.
8. Water penetration systems.

C. Water Samples: Specified in "Cleaning" article.

D. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Domestic water piping.
3. Compressed air piping.
4. HVAC hydronic piping.
5. HVAC Ductwork.

E. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61, NSF 372 for potable domestic water piping and components.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B88, Type L water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.

2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
5. Copper Pressure-Seal-Joint Fittings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Elkhart Products Corporation; Industrial Division.
        2) NIBCO INC.
        3) Viega; Plumbing and Heating Systems.

    b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.

    c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

6. Copper Push-on-Joint Fittings:

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) NVent LLC.
        2) ProBite Quick Fitting Inc.
        3) Viega; Plumbing and Heating Systems.

    b. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.

7. Grooved-Joint Copper-Tube Appurtenances:

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Anvil International.
        2) Shurjoint Piping Products.

3) Victaulic Company.

b. Copper Grooved-End Fittings: ASTM B75 copper tube or ASTM B584 bronze castings.

c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

B. Soft Copper Tube: ASTM B88, Type K water tube, annealed temper.

1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
2. Copper Pressure-Seal-Joint Fittings:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Elkhart Products Corporation; Industrial Division.
2) NIBCO INC.
3) Viega; Plumbing and Heating Systems.

b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.

c. NPS 3 and NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.

a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.

a. Gaskets: AWWA C111, rubber.

2. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.

a. Gaskets: AWWA C111, rubber.

C. Plain-End, Ductile-Iron Pipe: AWWA C151.

1. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:

a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Anvil International.
2) Shurjoint Piping Products.
3) Star Pipe Products.
4) Victaulic Company.

b. Grooved-End, Ductile-Iron Fittings: ASTM A47, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe.

c. Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105.

B. Form: Tube.

C. Material: High-density, cross-laminated PE film of 0.004-inch minimum thickness.

D. Color: Natural.

2.6 SPECIALTY VALVES

A. Comply with requirements in Section 22 05 23 for general-duty metal valves.

B. Comply with requirements in Section 22 11 19 for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.7 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. EPCO Sales, Inc.
d. Hart Industries International, Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

a. Pressure Rating: 150 psig at 180 degrees F.
b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Factory-fabricated, bolted, companion-flange assembly.
    b. Pressure Rating: 150 psig.
    c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Description:

    a. Non-conducting materials for field assembly of companion flanges.
    b. Pressure Rating: 150 psig.
    c. Gasket: Neoprene or phenolic.
    d. Bolt Sleeves: Phenolic or polyethylene.
    e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Calpico, Inc.
    b. Lochinvar Corporation.

2. Description:

    a. Galvanized-steel coupling.

b. Pressure Rating: 300 psig at 225 degrees F.
c. End Connections: Female threaded.
d. Lining: Inert and non-corrosive, thermoplastic.

F. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Perfection Corporation; a subsidiary of American Meter Company.
b. Precision Plumbing Products, Inc.

2. Description:

a. Electroplated steel nipple complying with ASTM F1545.
b. Pressure Rating: 300 psig at 225 degrees F.
c. End Connections: Male threaded or grooved.
d. Lining: Inert and non-corrosive, propylene.

2.9 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Cast Brass: Polished, chrome-plated finish with setscrews.

C. One-Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One-Piece, Stamped Steel: Chrome-plated finish with setscrew.

E. Split Casting, Cast Brass: Polished, chrome-plated with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew.

G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.10 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.11 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.12 WALL PENETRATION SYSTEMS

A. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.

1. Carrier-Pipe Deflection: Up to five (5) percent without leakage.
2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
3. Housing-to-Sleeve Gasket: EPDM rubber.
4. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber.

5. Pipe Sleeve: AWWA C151, ductile-iron pipe or ASTM A53, Schedule 40, zinc-coated steel pipe.

2.13 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 31 20 00 for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube in PE encasement according to ASTM A674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Section 22 05 19 for pressure gages and Section 22 11 19 for drain valves and strainers.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Section 22 11 19 for pressure-reducing valves.

H. Install domestic water piping level with max 0.25 percent slope downward toward drain and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install seismic restraints on piping. Comply with requirements in Section 22 05 48 for seismic-restraint devices.

K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

L. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

N. Install piping adjacent to equipment and specialties to allow service and maintenance.

O. Install piping to permit valve servicing.

P. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

Q. Install piping free of sags and bends.

R. Install fittings for changes in direction and branch connections.

S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

T. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Section 22 05 19 for pressure gages.

U. Install thermostats in hot-water circulation piping. Comply with requirements in Section 22 11 23 for thermostats.

V. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Section 22 05 19 for thermometers.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.

I. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

J. Steel-Piping Grooved Joints: Cut or roll groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

K. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

L. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 22 05 23 for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Section 22 11 19.

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Section 22 11 19 for balancing valves.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Section 22 11 19 for calibrated balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 1-1/2 and Smaller: Fitting-type coupling.

2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.

D. Dielectric Fittings for NPS 6 and Larger: Use dielectric flange kits.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless steel hose flexible connectors in steel domestic water piping.

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 22 05 48 for seismic-restraint devices.

B. Comply with requirements in Section 22 05 29 for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8-inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.

2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.

3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.

4. NPS 2-1/2: 108 inches with 1/2-inch rod.

5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

6. NPS 6: 10 feet with 5/8-inch rod.

7. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.

2. NPS 1-1/2: 108 inches with 3/8-inch rod.

3. NPS 2: 10 feet with 3/8-inch rod.

4. NPS 2-1/2: 11 feet with 1/2-inch rod.

5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.

6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

7. NPS 6: 12 feet with 3/4-inch rod.

8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

3.9 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.

2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture sections for connection sizes.
3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.10 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass with polished chrome-plated finish stamped steel with set screw.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast brass with polished chrome-plated finish
4. Bare Piping in Unfinished Service Spaces: One-piece, cast brass with polished chrome-plated finish.
5. Bare Piping in Equipment Rooms: One-piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:

1. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2. Insulated Piping: Split plate, stamped steel with concealed hinge and spring clips.
3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
5. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish.
6. Bare Piping in Equipment Rooms: Split casting, cast brass.
7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.11 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using wall penetration systems specified in this section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.

    a. Extend sleeves two (2) inches above finished floor level.
    b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level. Comply with requirements in Section 07 61 00 for flashing.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:

    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized steel sheet sleeves for pipes NPS 6 and larger.
    c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
5. Sleeves for Piping Passing through Exterior Concrete Walls:

    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
    c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

d. Do not use sleeves when wall penetration systems are used.

6. Sleeves for Piping Passing through Interior Concrete Walls:

a. Steel pipe sleeves for pipes smaller than NPS 6.
b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 07 84 13 for firestop materials and installations.

3.12 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.13 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.14 IDENTIFICATION

A. Identify system components. Comply with requirements in Section 22 05 53 for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.15 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

    a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 100 psig. Isolate test source and allow to stand for four (4) hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.16 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.17 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Submit water samples to an accredited lab for testing and submit successful results to OSBI for review. Repeat procedures if biological examination shows contamination.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.18 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building service piping, NPS 3 and smaller shall be one (1) of the following:

1. Soft copper tube, ASTM B88, Type K; wrought-copper solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one (1) of the following:
1. Mechanical-joint, ductile-iron pipe; standard-compact- pattern mechanical-joint fittings; and mechanical joints.
2. Push-on-joint, ductile-iron pipe; standard pattern push-on-joint fittings; and gasketed joints.
3. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

F. Under-building-slab, domestic water piping, NPS and smaller, shall be one (1) of the following:

1. Soft copper tube, ASTM B88, Type L; wrought-copper solder-joint fittings; and brazed joints.

G. Aboveground domestic water piping, NPS 2 and smaller, shall be one (1) of the following:

1. Hard copper tube, ASTM B88, Type L; cast- or wrought- copper solder-joint fittings; and brazed joints.

2. Hard copper tube, ASTM B88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L; copper push-on-joint fittings; and push-on joints.

H. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one (1) of the following:

1. Hard copper tube, ASTM B88, Type L; cast- or wrought- copper solder-joint fittings; and brazed soldered joints.
2. Hard copper tube, ASTM B88, Type L: copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L; grooved-joint copper-tube appurtenances; and grooved joints.

I. Aboveground domestic water piping, NPS 5 to NPS 8, shall be one (1) of the following:

J. Aboveground, combined domestic-water-service and fire-service-main piping, NPS 6 to NPS 12, shall be one (1) of the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
2. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
3. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

3.19 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Domestic water piping specialties including the following:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Strainers.
6. Outlet boxes.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water hammer arresters.
11. Air vents.
12. Trap-seal primer valves.
13. Trap-seal primer systems.

1.3 RELATED SECTIONS

A. Section 22 05 19 - Meters and Gages for Plumbing Piping: Thermometers, pressure gages, and flow meters in domestic water piping.

B. Section 22 32 00 - Domestic Water Filtration Equipment: Water filters in domestic water piping.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, NSF 372 "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Ames Co.
b. Conbraco Industries, Inc.
c. FEBCO; SPX Valves & Controls.
d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Pressure Vacuum Breakers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ames Co.
    b. Conbraco Industries, Inc.
    c. FEBCO; SPX Valves & Controls.
    d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: Five (5) psig maximum, through middle 1/3 of flow range.

    a. Valves: Ball type, on inlet and outlet.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ames Co.
    b. Conbraco Industries, Inc.
    c. FEBCO; SPX Valves & Controls.
    d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
4. Size: Line size as noted on plans.
5. Body: Bronze.
6. End Connections: Union, solder.
7. Finish: Rough bronze.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ames Co.
    b. Conbraco Industries, Inc.
    c. FEBCO; SPX Valves & Controls.
    d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for vertical inlet, horizontal center section, and vertical outlet, vertical flow.
8. Accessories:

    a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
    b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Beverage-Dispensing-Equipment Backflow Preventers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ames Co.
    b. Conbraco Industries, Inc.
    c. FEBCO; SPX Valves & Controls.
    d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.

D. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ames Co.
    b. Conbraco Industries, Inc.
    c. FEBCO; SPX Valves & Controls.
    d. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1032.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.

5. Body: Stainless steel.
6. End Connections: Threaded.

2.3 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Armstrong International, Inc.
   b. ITT Industries; Bell & Gossett Div.
   c. NIBCO INC.
   d. Watts Industries, Inc.; Water Products Div.

2. Type: Ball valve with two readout ports and memory setting indicator.
3. Body: bronze.
4. Size: Same as connected piping, but not larger than NPS 2.
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Armstrong International, Inc.
   b. ITT Industries; Bell & Gossett Div.
   c. NIBCO INC.
   d. Watts Industries, Inc.; Water Products Div.

2. Watts Industries, Inc.; Water Products Div. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.4 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron [with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and] for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:

    a. Strainers NPS 2 and Smaller: 0.033 inch.
    b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
    c. Strainers NPS 5 and Larger: 0.125 inch.

6. Drain: Factory-installed, hose-end drain valve.

2.5 HOSE BIBBS (HB)

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Wheel handle.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.6 WALL HYDRANTS (WH)

A. Vacuum Breaker Wall Hydrants:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Smith, Jay. R. Mfg. Co.; Division of Smith Industries, Inc.
   b. Watts Industries, Inc.; Water Products Div.
   c. Woodford Manufacturing Company.
   d. Zurn Plumbing Products Group; Light Commercial Operation.

2. Standard: ASSE 1019, Type A or Type B.
3. Type: Freeze-resistant, automatic draining with vacuum breaker.
4. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: 125 psig.
6. Operation: Loose key.
7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: NPS 3/4.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.8 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMTROL, Inc.
    b. MIFAB, Inc.
    c. PPP Inc.
    d. Sioux Chief Manufacturing Company, Inc.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.9 TRAP-SEAL PRIMER VALVES

A. Drainage-Type, Trap-Seal Primer Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    b. MIFAB, Inc.
    c. Sioux Chief.

2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
3. Size: NPS 1-1/4 minimum.
4. Material: Chrome-plated, cast brass.

2.10 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. MIFAB, Inc.
    b. Precision Plumbing Products Inc.
    c. Zurn Industries, LLC.

2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B88, Type L; copper, water tubing.
4. Cabinet: Surface-mounting steel box with stainless-steel cover.

5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: As noted on Plans.
8. Size Outlets: NPS 1/2.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 22 05 00 for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

D. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

E. Install balancing valves in locations where they can easily be adjusted.

F. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

G. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve, solenoid valve, and pump.

H. Install water hammer arresters in water piping according to PDI-WH 201.

I. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

J. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of one (1) percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

K. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of one (1) percent, and connect to floor-drain body, trap, or inlet fitting.

L. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of one (1) percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Section 26 05 26.

C. Connect wiring according to Section 26 05 19.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
4. Double-check backflow-prevention assemblies.
5. Carbonated-beverage-machine backflow preventers.
6. Dual-check-valve backflow preventers.
7. Double-check, detector-assembly backflow preventers.
8. Water pressure-reducing valves.
9. Calibrated balancing valves.
10. Primary, thermostatic, water mixing valves.
11. Manifold, thermostatic, water-mixing-valve assemblies.
12. Photographic-process, thermostatic, water-mixing-valve assemblies.
13. Primary water tempering valves.
14. Outlet boxes.
15. Hose stations.
16. Supply-type, trap-seal primer valves.

17. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Soil, waste, and vent piping inside the building including the following:

1. Pipe, tube, and fittings.
2. Special pipe fittings.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For pipe, tube, fittings, and couplings.

C. Shop Drawings:

1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. Shielded Couplings: ASTM C-1540 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Standard, Shielded, Stainless steel Couplings: Above Slab, FM 1680, Class 1, with Type 304 AISI stainless steel corrugated shield with a thickness of 0.010, stainless steel bands and tightening devices; and ASTM C564 neoprene gasket.

a. Manufacturers:
   1) Husky Coupling
   2) Ideal Div.; Stant Corp.
   3) Mission Rubber CO.

1. Heavy-Duty, Shielded, Stainless steel Couplings: Below Slab, FM 1680, Class 1, with Type 304 AISI stainless steel corrugated shield with a thickness of 0.015, stainless steel bands and tightening devices; and ASTM C564 neoprene gasket.

   a. Manufacturers:
      1) Husky Coupling
      2) Ideal Div.; Stant Corp.
      3) Mission Rubber CO.

2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A48, two-piece, cast-iron housing; stainless steel bolts and nuts; and ASTM C564, rubber sleeve.

   a. Manufacturers:

      1) MG Piping Products Co.

      2) Ideal

      3) Mission Rubber CO.

C. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

   1. Manufacturers:

      a. ANACO.

      b. Ideal

      c. Fernco

2.4 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B306, drainage tube, drawn temper.

   1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B88, Types L and M, water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

C. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Section 31 20 00 for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 6 and smaller shall be any of the following:
1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless steel couplings; and hubless-coupling joints.
2. Dissimilar Pipe-Material Couplings: Shielded**,** non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, vent piping NPS 4 and smaller shall be the following:
1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless steel couplings; and hubless-coupling joints.
2. Steel pipe, drainage fittings, and threaded joints.

D. Underground, soil, waste, and vent piping NPS 6 and smaller shall be any of the following:
1. Hubless cast-iron soil pipe and fittings; heavy duty, shielded, stainless steel couplings; and hubless-coupling joints.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping 5’-0” outside the building is specified in Division 2.

B. Basic piping installation requirements are specified in Section 22 05 00.

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 22 05 48.

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install underground, ductile-iron, special pipe fittings according to AWWA C600.

1. Install encasement on piping according to ASTM A674 or AWWA C105.

F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 22 05 00.

G. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

H. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A674 or AWWA C105.

I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two (2) fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: Two (2) percent downward in direction of flow for piping NPS 3 and smaller; one (1) percent downward in direction of flow for piping NPS 4 and larger.

2. Horizontal Sanitary Drainage Piping: Two (2) percent downward in direction of flow.
3. Vent Piping: One (1) percent down toward vertical fixture vent or toward vent stack.

L. Install engineered soil and waste drainage and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 07 84 13.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 05 00.

B. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 22 05 48.

B. Pipe hangers and supports are specified in Section 22 05 29. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Section 22 05 29.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one (1) size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.

2. NPS 3: 60 inches with 1/2-inch rod.

3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

4. NPS 6: 60 inches with 3/4-inch rod.

5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of all piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Sanitary drainage piping specialties including the following:
   1. Cleanouts.
   2. Floor drains.
   3. Air-admittance valves.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials.

1.3 RELATED SECTIONS

A. Section 22 14 13 – Facility Storm Drainage Piping: Trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

B. Section 22 42 00 - Commercial Plumbing Fixtures.

1.4 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene plastic.

D. PE: Polyethylene plastic.

E. PP: Polypropylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
   1. Cleanouts.
   2. Floor drains.
   3. Air-admittance valves.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials.

C. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.

   1. Wiring Diagrams: Power, signal, and control wiring.

D. Manufacturer Seismic Qualification Certification: Submit certification that FOG disposal systems, accessories, and components will withstand seismic forces defined in Section 22 05 48. Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00.

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Josam Company.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.
d. Wade.
e. Watts.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.

B. Metal Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Josam Company.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.
d. Wade.
e. Watts.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Threaded.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Square.
12. Top Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Wade.
    e. Watts.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk cast-iron plug.
6. Closure Plug Size: Same as or not more than one (1) size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless steel cover plate with screw.
8. Wall Access: Round nickel-bronze, copper-alloy, or stainless steel wall-installation frame and cover.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains: Refer to Drawing P1.00 for description.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Wade.
    e. Watts.

B. Floor Drains: Refer to Drawing P1.01 for Description.
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.
    d. Wade.
    e. Watts.

2. Standard: ASME A112.3.1.

2.3 AIR-ADMITTANCE VALVES

A. Fixture Air-Admittance Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
    a. Durgo, Inc.
    b. Oatey.
    c. ProSet Systems Inc.
    d. Studor, Inc.

2. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
3. Housing: Plastic.
4. Operation: Mechanical sealing diaphragm.
5. Size: Same as connected fixture or branch vent piping.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2: 4-inch minimum water seal.

b. NPS 2-1/2 and Larger: 5-inch minimum water seal.

B. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Sure Seal trap sealer device or approved equal.

C. Air-Gap Fittings :

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, which forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend two (2) inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps :

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.5 FOG DISPOSAL SYSTEMS

A. FOG Disposal Systems :
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
a. Proceptor

b. Xerxes
c. Containment Solutions

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Section 22 05 00 for piping joining materials, joint construction, and basic installation requirements.

B. Install backwater valves in building drain piping. For interior installation, provide

cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. Install cleanouts in all horizontal drains including branch drains according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

    a. Radius, 30 Inches or Less: Equivalent to one (1) percent slope, but not less than 1/4-inch total depression.
    b. Radius, 30 to 60 Inches: Equivalent to one (1) percent slope.
    c. Radius, 60 Inches or Larger: Equivalent to one (1) percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

G. Install fixture air-admittance valves on fixture drain piping.

H. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

I. Install deep-seal traps on floor drains and other waste outlets, if indicated.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install vent caps on each vent pipe passing through roof.

N. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

O. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

P. CONN Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 07 84 13.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq ft, 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq ft, 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least eight (8) inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least eight (8) inches around sleeve.

3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least eight (8) inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 07 62 00.

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

H. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled FOG disposal systems and their installation, including piping and electrical connections, and to assist in testing.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops. Cap or plug shall be the same or compatible piping material.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain FOG disposal systems and grease removal devices. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Pipe, tube, and fittings.
   1. Special pipe fittings.
   2. Encasement for underground metal piping.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. LLDPE: Linear, low-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PVC: Polyvinyl chloride plastic.

E. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:

   1. Storm Drainage Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For pipe, tube, fittings, and couplings.

C. Shop Drawings:

1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
2. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.

D. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" article for applications of pipe, tube, fitting, and joining materials.

2.3 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. Shielded Couplings: ASTM C-1540 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Standard, Shielded, Stainless steel Couplings: Above Slab, FM 1680, Class 1, with Type 304 AISI stainless steel corrugated shield with a thickness of 0.010, stainless steel bands and tightening devices; and ASTM C564 neoprene gasket.

a. Manufacturers:
   1) Husky Coupling
   2) Ideal Div.; Stant Corp.
   3) Mission Rubber CO.

1. Heavy-Duty, Shielded, Stainless steel Couplings: Below Slab, FM 1680, Class 1, with Type 304 AISI stainless steel corrugated shield with a thickness of 0.015, stainless steel bands and tightening devices; and ASTM C564 neoprene gasket.

   a. Manufacturers:
      1) Husky Coupling
      2) Ideal Div.; Stant Corp.
      3) Mission Rubber CO.

2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A48, two-piece, cast-iron housing; stainless steel bolts and nuts; and ASTM C564, rubber sleeve.

   a. Manufacturers:

      1) MG Piping Products Co.
      2) Ideal
      3) Mission Rubber CO.

C. Rigid, Unshielded Couplings: ASTM C1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

   1. Manufacturers:

      a. ANACO.
      b. Dallas Specialty & Mfg Co.
      c. Fernco, Inc.

2.4 ROOF DRAINS

A. Refer to schedule on drawings

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Section 31 20 00 for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping NPS 8 and smaller shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless steel couplings; and coupled joints.

C. Aboveground, storm drainage piping NPS 10 and larger shall be any of the following:

   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless steel couplings; and coupled joints.

D. Underground storm drainage piping NPS 10 and smaller shall be the following:
   1. Hubless cast-iron soil pipe and fittings; standard, heavy duty shielded, stainless steel couplings; and coupled joints.

3.3 PIPING INSTALLATION

A. Storm and drainage piping outside the building are specified in Section 33 41 00.

B. Basic piping installation requirements are specified in Section 22 05 00.

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 22 05 48.

D. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Section 22 14 23.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Section 22 05 00.

F. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.

G. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Section 07 84 13.

H. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A674 or AWWA C105.

I. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

K. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: One (1) percent downward in direction of flow for piping NPS 3 and smaller; one (1) percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: Two (2) percent downward in direction of flow.

L. Install engineered controlled-flow storm drainage piping in locations indicated.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Section 22 05 00.

B. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

C. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Section 22 05 48.

B. Pipe hangers and supports are specified in Section 22 05 29. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Section 22 05 29.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one (1) size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.

2. NPS 3: 60 inches with 1/2-inch rod.

3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

4. NPS 6: 60 inches with 3/4-inch rod.

5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 84 inches with 3/8-inch rod.

2. NPS 1-1/2: 108 inches with 3/8-inch rod.

3. NPS 2: 10 feet with 3/8-inch rod.

4. NPS 2-1/2: 11 feet with 1/2-inch rod.

5. NPS 3: 12 feet with 1/2-inch rod.

6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

7. NPS 6: 12 feet with 3/4-inch rod.

8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports, signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 100 psig. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Conventional plumbing fixtures and related components including the following:

1. Faucets for lavatories.
2. Laminar-flow faucet-spout outlets.
3. Flushometers.
4. Toilet seats.
5. Protective shielding guards.
6. Fixture supports.
7. Water closets.
8. Urinals.
9. Lavatories.
10. Owner-furnished fixtures and equipment.

1.3 RELATED SECTIONS

A. Section 10 28 00 - Toilet, Bath, and Laundry Accessories.

B. Section 22 11 19 - Domestic Water Piping Specialties: Backflow preventers, floor drains, and specialty fixtures not included in this section.

C. Section 22 32 00 - Domestic Water Filtration Equipment: Water filters.

1.4 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this section.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one (1) source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, NSF 372, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
   2. Vitreous-China Fixtures: ASME A112.19.2M.

H. Comply with the following applicable standards and other requirements specified for lavatory faucets:

   1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   4. Faucets: ASME A112.18.1.
   5. Hose-Connection Vacuum Breakers: ASSE 1011.
   6. Hose-Coupling Threads: ASME B1.20.7.
   7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   8. NSF Potable-Water Materials: NSF 61, NSF 372.
   9. Pipe Threads: ASME B1.20.1.
   10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   11. Supply Fittings: ASME A112.18.1.
   12. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

   1. Atmospheric Vacuum Breakers: ASSE 1001.
   2. Brass and Copper Supplies: ASME A112.18.1.
   3. Dishwasher Air-Gap Fittings: ASSE 1021.
   4. Manual-Operation Flushometers: ASSE 1037.
   5. Plastic Tubular Fittings: ASTM F409.
   6. Brass Waste Fittings: ASME A112.18.2.
   7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   1. Flexible Water Connectors: ASME A112.18.6.
   2. Floor Drains: ASME A112.6.3.
   3. Hose-Coupling Threads: ASME B1.20.7.

4. Off-Floor Fixture Supports: ASME A112.6.1M.
5. Pipe Threads: ASME B1.20.1.
6. Plastic Toilet Seats: ANSI Z124.5.
7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.7 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures of unit shell.
b. Faulty operation of controls, blowers, pumps, heaters, and timers.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: One (1) year(s) from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to five (5) percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Flushometer Tank, Repair Kits: Equal to five (5) percent of amount of each type installed, but no fewer than two (2) of each type.
6. Toilet Seats: Equal to five (5) percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets: Refer to Schedule on Drawings.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following;
   a. Grohe
   b. Symmons Industries.
   c. Chicago Faucets.
   d. Delta Faucet Company.
   e. Sloan
   f. Speakman Company.
   g. Hydrotek

2.2 FLUSHOMETERS

A. Flushometers: Refer to Schedule on Drawings.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Speakman
   b. Toto
   c. Sloan Valve Company.
   d. Hydrotek

2.3 SHOWERS

A. Showers: Refer to Schedule on Drawings.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Fiat
   b. Kohler
   c. American Standard

2.4 TOILET SEATS

A. Toilet Seats: Refer to Schedule on Drawing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
   a. Toto.
   b. Bemis Manufacturing Company.
   c. Church Seats.
   d. Olsonite Corp.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Engineered Brass Co.
   b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
   c. McGuire Manufacturing Co., Inc.
   d. Plumberex Specialty Products Inc.
   e. TCI Products.
   f. TRUEBRO, Inc.
   g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. TRUEBRO, Inc.
   b. Plumberex Specialty Products, Inc.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.6 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Josam Company.

2. Smith, Jay R. Mfg. Co.
3. Tyler Pipe; Wade Div.
4. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
5. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible, i.e., standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

2.7 WATER CLOSETS

A. Water Closets: Refer to Schedule on Drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Toto.
b. Sloan
c. American Standard Companies, Inc.
d. Kohler Co.

2.8 CHINA LAVATORIES

A. Lavatories: Refer to Schedule on Drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Toto
b. Sloan
c. American Standard Companies, Inc.
d. Kohler Co.

2.9 LAVATORIES

A. Lavatories: Refer to Schedule on Drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Toto
b. Sloan
c. Willoughby
d. Acorn
e. Intersan

2. Undermount, porcelain lavatory system with solid metal turning option to eliminate all the plastic parts in the lav systems and assure all pushbuttons, sprayheads, escutcheons and grid drains stainless steel or brass…not plastic.
3. The lavatory system shall accommodate from 1 to 3 users simultaneously.
4. The lavatory system bowl, top and pedestal panels shall be constructed of AquaSurf molded cast polymer densified solid surface material composed of polyester/acrylic resin, UV stabilizer, aluminum trihydrate and mineral fillers.
5. The pre-assembled water distribution heads and pedestal base shall be constructed of 16 gauge, type 304 stainless steel.
6. Exposed stainless surfaces shall be polished to a satin finish. Water spray nozzles shall be machined from type 303 stainless steel (no plastic allowed). The drain grates shall be machined from type 303 stainless steel.
7. The pre-assembled sprayhead module shall be equipped with independent spray nozzles, each controlled by a separate infrared sensor.
8. Flow restrictor shall maintain flow rates at .5 gpm per station.
9. The lavatory system shall be supplied with thermostatic mixing, checkstops and strainers, drain spuds, flexible supply hoses, control valves, color coated water lines, and Class II 120/24VAC plug-in transformer.
10. Solid surface front panels must be easily removable for maintenance access.

2.10 Mop Basins

A. Mop Basins: Refer to Schedule on Drawings:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Fiat
b. Williams
c. Mustee

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Section 22 05 23.

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install shower flow-control fittings with specified maximum flow rates in shower arms.

S. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

T. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

U. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install Sink Tailpiece. Connect inlet hose to dishwasher and outlet hose to disposer.

V. Install hot-water dispensers in back top surface of sink or in countertop with spout over sink.

W. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 22 05 00.

X. Set shower receptors and service basins in leveling bed of cement grout. Grout is specified in Section 22 05 00.

Y. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Section 07 92 00.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Section 26 05 26.

D. Connect wiring according to Section 26 05 19.

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Piping materials and installation instructions common to most piping systems.

B. Transition fittings.

C. Dielectric fittings.

D. Mechanical sleeve seals.

E. Sleeves.

F. Escutcheons.

G. Grout.

H. HVAC demolition.

I. Equipment installation requirements common to equipment sections.

J. Painting and finishing.

K. Concrete bases.

L. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31.9–2011, B31.1-2012, B31.3-2012, B31.5-2013, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8-inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F493.
2. PVC Piping: ASTM D2564. Include primer according to ASTM F656.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

a. Eslon Thermoplastics.
b. NIBCO Inc.
c. Spears.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturers:

a. Thompson Plastics, Inc.
b. NIBCO Inc.
c. Spears.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

1. Manufacturers:

a. NIBCO INC.
b. NIBCO, Inc.; Chemtrol Div.
c. Spears.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 degrees F.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.

d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.

1. Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.
c. Mueller Industries, Inc.

G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F.

1. Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.

c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: **EPDM** interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: **Carbon steel**. Include two (2) for each sealing element.
4. Connecting Bolts and Nuts: **Carbon steel with corrosion-resistant coating** of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: **Polished chrome-plated**.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: **Polished chrome-plated**.

E. One-Piece, Stamped-Steel Type: With **set screw or spring clips** and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With **concealed** hinge, **set screw or spring clips**, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Section 01 73 29 and Section 02 41 19 for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: **One-piece or split-casting**, cast-brass type with polished chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with **rough-brass** finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with **concealed or exposed-rivet** hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   e. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with **rough-brass** finish.
   f. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. **Steel** Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level. Refer to Section 07 62 00 for flashing.

        1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07 92 00 for materials and installation.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than six (6) inches in diameter.
2. Install cast-iron "wall pipes" for sleeves six (6) inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07 84 13 for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other sections of these specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846 Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
4. PVC Non-pressure Piping: Join according to ASTM D2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Section 09 91 00.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at project.

1. Construct concrete bases of dimensions indicated, but not less than four (4) inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use **3000-psi**, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 05 50 00 for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. General requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 RELATED SECTIONS

A. Section 26 29 13 - Enclosed Controllers.

1. Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

B. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1. Variable-frequency motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

1.4 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this section except when stricter requirements are specified in HVAC equipment schedules or sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degrees C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Class B.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Shaft Grounding Ring: Whenever variable frequency PWM drives are installed to control AC motors, provide a circumferential, conductive micro fiber shaft grounding ring, similar to AEGIS SGR Bearing Protection Ring, shall be installed on the AC motor to discharge shaft currents to ground.

   a. Motors up to 100 HP: Install a shaft grounding ring on either the drive end or the non-drive end of the motor in accordance with manufacturer’s installation instructions.
   b. Motors over 100 HP: Insulate one bearing journal or install ceramic bearing, on the non-drive end of the motor. Install a shaft grounding ring on the opposite end in accordance with manufacturer’s installation instructions.

2. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
3. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
4. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
5. See "Multispeed and Variable-Speed Considerations" article in the Evaluations for discussion of thermally protected motors. Thermal protection is not usually required for HVAC equipment and energy- or premium-efficient motors specified in this section. Retain subparagraph below to require the added protection from overheating or if inverter-duty motors are required.
6. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Flexible-hose packless expansion joints.

B. Pipe loops and swing connections.

C. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: For each type of product indicated.

C. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.

4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

D. Welding certificates.

E. Product Certificates: For each type of expansion joint, from manufacturer.

F. Maintenance Data: For expansion joints to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

A. Flexible-Hose Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Flex Pression Ltd.
d. Metraflex, Inc.
e. Unisource Manufacturing, Inc.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two (2) flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 degrees F and 340 psig at 450 degrees F ratings.

5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

a. Stainless steel hoses and single-braid, stainless steel sheaths with 300 psig at 70 degrees F and 225 psig at 450 degrees F ratings.

6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

    a. Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 degrees F and 325 psig at 600 degrees F ratings.

7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with weld end connections.

    a. Stainless steel hoses and single-braid, stainless steel sheaths with 200 psig at 70 degrees F and 145 psig at 600 degrees F ratings.

8. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with weld end connections.

    a. Stainless steel hoses and single-braid, stainless steel sheaths with 125 psig at 70 degrees F and 90 psig at 600 degrees F ratings.

9. Expansion Joints for Steel Piping NPS 14 and Larger: Carbon-steel fittings with weld end connections.

    a. Stainless steel hoses and double-braid, stainless steel sheaths with 165 psig at 70 degrees F and 120 psig at 600 degrees F ratings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Adsco Manufacturing LLC.
    b. Advanced Thermal Systems, Inc.
    c. Flex-Hose Co., Inc.
    d. Flexicraft Industries.
    e. Flex-Weld, Inc.
    f. Hyspan Precision Products, Inc.
    g. Metraflex, Inc.
    h. Senior Flexonics Pathway.
    i. Unisource Manufacturing, Inc.
    j. U.S. Bellows, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five (5) pipe fittings including tee in main.

C. Connect risers and branch connections to terminal units with at least four (4) pipe fittings including tee in riser.

D. Connect mains and branch connections to terminal units with at least four (4) pipe fittings including tee in main.

3.2 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two (2) guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four (4) pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Sleeves.

B. Stack-sleeve fittings.

C. Sleeve-seal systems.

D. Sleeve-seal fittings.

E. Grout.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized Steel Wall Pipes: ASTM A53, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized Steel Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Galvanized Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded PE or PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Smith, Jay R. Mfg. Co.
2. Thaler Metal.
3. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel, with corrosion-resistant coating.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Presealed Systems – HoldRite, HydroFlame.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes, except for holes located in the floors of mechanical equipment rooms.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded PE or PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas two (2) inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00.
3. Install section of cast-iron soil pipe to extend sleeve to two (2) inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6: Cast-iron wall sleeves, Galvanized steel wall sleeves, Galvanized steel pipe sleeves, or Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Cast-iron wall sleeves, Galvanized steel wall sleeves, Galvanized steel pipe sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized steel wall sleeves with sleeve-seal system, Galvanized steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized steel wall sleeves with sleeve-seal system, Galvanized steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized steel wall sleeves with sleeve-seal system, Galvanized steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized steel wall sleeves with sleeve-seal system, Galvanized steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Galvanized steel pipe sleeves, Stack-sleeve fittings, or Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Galvanized steel pipe sleeves, or Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Galvanized steel pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized steel sheet sleeves.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Escutcheons.

B. Floor plates.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with rough-brass finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with rough-brass finish.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

2. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.

e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
g. Bare Piping in Unfinished Service Spaces: Split-casting brass type with rough-brass finish.
h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with exposed-rivet hinge.
i. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.
j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with exposed-rivet hinge.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Bimetallic-actuated thermometers.

B. Filled-system thermometers.

C. Liquid-in-glass thermometers.

D. Light-activated thermometers.

E. Thermowells.

F. Dial-type pressure gages.

G. Gage attachments.

H. Test plugs.

I. Test-plug kits.

J. Sight flow indicators.

K. Orifice flowmeters.

L. Pitot-tube flowmeters.

M. Turbine flowmeters.

N. Venturi flowmeters.

O. Vortex-shedding flowmeters.

P. Impeller-turbine, thermal-energy meters.

Q. Ultrasonic, thermal-energy meters.

1.3 RELATED SECTIONS

A. Section 22 21 23 - Facility Natural-Gas Piping: Gas meters.

1.4 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: For each type of product indicated.

C. Wiring Diagrams: For power, signal, and control wiring.

D. Product Certificates: For each type of meter and gage, from manufacturer.

E. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Miljoco Corporation.
5. Nanmac Corporation.
6. Noshok.
7. Palmer Wahl Instrumentation Group.
8. REOTEMP Instrument Corporation.
9. Tel-Tru Manufacturing Company.
10. Trerice, H. O. Co.
11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
12. Weiss Instruments, Inc.
13. WIKA Instrument Corporation - USA.
14. Winters Instruments - U.S.

B. Standard: ASME B40.200.

C. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.

D. Dial: Non-reflective aluminum with permanently etched scale markings and scales in degrees F.

E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

F. Connector Size: 1/2-inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass or plastic.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus one (1) percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Ashcroft Inc.
b. Marsh Bellofram.
c. Miljoco Corporation.
d. Palmer Wahl Instrumentation Group.
e. REOTEMP Instrument Corporation.
f. Trerice, H. O. Co.
g. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.

11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one (1) percent of scale range.

B. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ashcroft Inc.
    b. Miljoco Corporation.
    c. REOTEMP Instrument Corporation.

2. Standard: ASME B40.200.
3. Case: Sealed type, plastic; 5-inch nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or plastic.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one (1) percent of scale range.

C. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Marsh Bellofram.
    d. Miljoco Corporation.
    e. Palmer Wahl Instrumentation Group.
    f. REOTEMP Instrument Corporation.

g. Trerice, H. O. Co.
h. Weiss Instruments, Inc.
i. WIKA Instrument Corporation - USA.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 6-inch nominal diameter with back or front flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal.
10. Connector Type(s): Union joint, back; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one (1) percent of scale range.

D. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Miljoco Corporation.
    d. REOTEMP Instrument Corporation.
    e. Trerice, H. O. Co.

2. Standard: ASME B40.200.
3. Case: Sealed type, plastic; 6-inch nominal diameter with back flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or plastic.
10. Connector Type(s): Union joint, threaded, back; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus one (1) percent of scale range or one (1) scale division, to a maximum of 1.5 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Trerice, H. O. Co.
b. Weksler Glass Thermometer Corp.
c. Winters Instruments.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

9. Connector: 3/4-inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one (1) percent of scale range or one (1) scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Flo Fab Inc.
b. Miljoco Corporation.
c. Tel-Tru Manufacturing Company.
d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
e. Weiss Instruments, Inc.
f. WIKA Instrument Corporation - USA.

2. Standard: ASME B40.200.

3. Case: Plastic; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Non-reflective with permanently etched scale markings graduated in degrees F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 3/4-inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one (1) percent of scale range or one (1) scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Flo Fab Inc.
    b. Miljoco Corporation.
    c. Palmer Wahl Instrumentation Group.
    d. Tel-Tru Manufacturing Company.
    e. Trerice, H. O. Co.
    f. Weiss Instruments, Inc.
    g. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one (1) percent of scale range or one (1) scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Ernst Flow Industries.
    b. Marsh Bellofram.
    c. Miljoco Corporation.
    d. Palmer Wahl Instrumentation Group.
    e. REOTEMP Instrument Corporation.
    f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    g. Weiss Instruments, Inc.
    h. WIKA Instrument Corporation - USA.

2. Standard: ASME B40.200.
3. Case: Plastic; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
7. Window: Glass or plastic.
8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus one (1) percent of scale range or one (1) scale division, to a maximum of 1.5 percent of scale range.

2.4 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Flo Fab Inc.
    b. REOTEMP Instrument Corporation.
    c. Trerice, H. O. Co.
    d. Weiss Instruments, Inc.
    e. WIKA Instrument Corporation - USA.
    f. Winters Instruments - U.S.

2. Case: Plastic; 7-inch nominal size unless otherwise indicated.
3. Scale(s): Degrees F.
4. Case Form: Adjustable angle.

5. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

7. Display: Digital.
8. Accuracy: Plus or minus two (2) degrees F.

B. Remote-Mounted, Light-Activated Thermometers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Miljoco Corporation.
    b. Weiss Instruments, Inc.
    c. Winters Instruments - U.S.

2. Case: Plastic, for wall mounting.
3. Scale(s): Degrees F.
4. Sensor: Bulb and thermister wire.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

5. Display: Digital.
6. Accuracy: Plus or minus two (2) degrees F.

2.5 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.6 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and one (1) inch, with ASME B1.1 screw threads.

8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.7 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMETEK, Inc.; U.S. Gauge.
b. Ashcroft Inc.
c. Ernst Flow Industries.
d. Flo Fab Inc.
e. Marsh Bellofram.
f. Miljoco Corporation.
g. Noshok.
h. Palmer Wahl Instrumentation Group.
i. REOTEMP Instrument Corporation.
j. Tel-Tru Manufacturing Company.
k. Trerice, H. O. Co.
l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
m. Weiss Instruments, Inc.
n. WIKA Instrument Corporation - USA.
o. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Flo Fab Inc.
    d. Marsh Bellofram.
    e. Miljoco Corporation.
    f. Noshok.
    g. Palmer Wahl Instrumentation Group.
    h. REOTEMP Instrument Corporation.
    i. Tel-Tru Manufacturing Company.
    j. Trerice, H. O. Co.
    k. Weiss Instruments, Inc.
    l. WIKA Instrument Corporation - USA.
    m. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type; plastic; 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
    1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        a. AMETEK, Inc.; U.S. Gauge.
        b. Ashcroft Inc.
        c. Ernst Flow Industries.
        d. Flo Fab Inc.
        e. Marsh Bellofram.
        f. Miljoco Corporation.
        g. Noshok.
        h. Palmer Wahl Instrumentation Group.
        i. REOTEMP Instrument Corporation.
        j. Tel-Tru Manufacturing Company.
        k. Trerice, H. O. Co.
        l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.

m. Weiss Instruments, Inc.
n. WIKA Instrument Corporation - USA.
o. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type; cast aluminum or drawn steel; 6-inch nominal diameter with back or front flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Metal.
11. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. AMETEK, Inc.; U.S. Gauge.
b. Ashcroft Inc.
c. Miljoco Corporation.
d. Noshok.
e. Palmer Wahl Instrumentation Group.
f. REOTEMP Instrument Corporation.
g. Tel-Tru Manufacturing Company.
h. Trerice, H. O. Co.
i. Weiss Instruments, Inc.
j. WIKA Instrument Corporation - USA.
k. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type; plastic; 6-inch nominal diameter with back or front flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Accuracy: Grade A, plus or minus one (1) percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 degrees F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Flow Design, Inc.
2. Miljoco Corporation.

3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Furnish one (1) test-plug kit(s) containing one (1) thermometer(s), one (1) pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 degrees F.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.11 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Archon Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Brooks Instrument.
4. Ernst Co., John C., Inc.
5. Ernst Flow Industries.
6. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
7. OPW Engineered Systems; a Dover company.
8. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 125 psig.

E. Minimum Temperature Rating: 200 degrees F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

2.12 FLOWMETERS

A. Orifice Flowmeters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABB; Instrumentation and Analytical.
b. Bell & Gossett; ITT Industries.
c. Meriam Process Technologies.
d. Preso Meters; a division of Racine Federated Inc.
e. S. A. Armstrong Limited; Armstrong Pumps Inc.

2. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.

a. Design: Differential-pressure-type measurement for water.
b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
c. Minimum Pressure Rating: 300 psig.
d. Minimum Temperature Rating: 250 degrees F.

5. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two (2) 12-foot hoses, with carrying case.

a. Scale: Gallons per minute.
b. Accuracy: Plus or minus two (2) percent between 20 and 80 percent of scale range.

6. Display: Shows rate of flow, with register to indicate total volume in gallons.
7. Conversion Chart: Flow rate data compatible with sensor and indicator.
8. Operating Instructions: Include complete instructions with each flowmeter.

B. Pitot-Tube Flowmeters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABB; Instrumentation and Analytical.
b. Emerson Process Management; Rosemount.

c. Meriam Process Technologies.
d. Preso Meters; a division of Racine Federated Inc.
e. TACO Incorporated.
f. Veris Industries, Inc.

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Insertion type; for inserting probe into piping and measuring flow directly in gallons per minute.

a. Design: Differential-pressure-type measurement for water.
b. Construction: Stainless steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
c. Minimum Pressure Rating: 150 psig.
d. Minimum Temperature Rating: 250 degrees F.

5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Integral Transformer: For low-voltage power connection.
7. Accuracy: Plus or minus three (3) percent.
8. Display: Shows rate of flow, with register to indicate total volume in gallons.
9. Operating Instructions: Include complete instructions with each flowmeter.

C. Turbine Flowmeters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABB; Instrumentation and Analytical.
b. Data Industrial Corp.
c. EMCO Flow Systems; a division of Spirax Sarco, Inc.
d. ERDCO Engineering Corp.
e. Hoffer Flow Controls, Inc.
f. Liquid Controls; a unit of IDEX Corporation.
g. McCrometer, Inc.
h. Midwest Instruments & Controls Corp.
i. ONICON Incorporated.
j. SeaMetrics, Inc.
k. Sponsler, Inc.; a unit of IDEX Corporation.

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute.

a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for water.
b. Construction: Bronze or stainless steel body, with plastic turbine or impeller.
c. Minimum Pressure Rating: 150 psig.
d. Minimum Temperature Rating: 180 degrees F.

5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus 1-1/2 percent.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

D. Venturi Flowmeters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABB; Instrumentation and Analytical.
b. Gerand Engineering Co.
c. Hyspan Precision Products, Inc.
d. Preso Meters; a division of Racine Federated Inc.
e. S. A. Armstrong Limited; Armstrong Pumps Inc.
f. Victaulic Company.

2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.

a. Design: Differential-pressure-type measurement for water.
b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
c. Minimum Pressure Rating: 250 psig.
d. Minimum Temperature Rating: 250 degrees F.
e. End Connections for NPS 2 and Smaller: Threaded.
f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

5. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two (2) 12-foot hoses, with carrying case.

a. Scale: Gallons per minute.

b. Accuracy: Plus or minus two (2) percent between 20 and 80 percent of scale range.

6. Display: Shows rate of flow, with register to indicate total volume in gallons.
7. Conversion Chart: Flow rate data compatible with sensor.
8. Operating Instructions: Include complete instructions with each flowmeter.

E. Vortex-Shedding Flowmeters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABB; Instrumentation and Analytical.
b. Eastech Flow Controls.
c. EMCO Flow Systems; a division of Spirax Sarco, Inc.
d. Emerson Process Management; Rosemount.
e. Endress+Hauser.
f. ISTEC Corporation.

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute.

a. Design: Flow obstruction device, vortex-measurement type for liquids.
b. Construction: Stainless steel body, with integral transmitter and direct-reading scale.
c. Minimum Pressure Rating: 1000 psig.
d. Minimum Temperature Rating: 500 degrees F.
e. Integral Transformer: For low-voltage power operation.

5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus 0.25 percent for liquids and 0.75 percent for gases.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

2.13 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Data Industrial Corp.
b. Hoffer Flow Controls, Inc.

c. ISTEC Corporation.
d. ONICON Incorporated.

2. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

    a. Design: Total thermal-energy measurement.
    b. Minimum Pressure Rating: 150 psig.
    c. Minimum Temperature Range: 40 to 250 degrees F.

4. Temperature Sensors: Insertion-type transducer.
5. Indicator: Solid-state, integrating-type meter with integral battery pack; for wall mounting.

    a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
    b. Battery Pack: Five-year lithium battery.

6. Accuracy: Plus or minus one (1) percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Strainer: Full size of main line piping.
9. Operating Instructions: Include complete instructions with each thermal-energy meter system.

B. Ultrasonic, Thermal-Energy Meters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. EMCO Flow Systems; a division of Spirax Sarco, Inc.
    b. FLEXIM AMERICAS Corporation.
    c. Siemens Energy & Automation, Inc.

2. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Transit-time ultrasonic type with transmitter.
4. Temperature Sensors: Insertion-type or strap-on transducer.
5. Indicator: Solid-state, integrating-type meter with integral battery pack.

    a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
    b. Battery Pack: Five-year lithium battery.

6. Accuracy: Plus or minus one (1) percent.

7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers as indicated on the drawings and in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two (2) inlets and two (2) outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two (2) inlets and two (2) outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages as indicated on the drawings and in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlets and outlets of each chiller shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

G. Thermometers at inlet and outlet of each thermal-storage tank shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with EPDM self-sealing rubber inserts.

H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one (1) of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.

I. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 degrees F.

B. Scale Range for Condenser-Water Piping: 0 to 150 degrees F.

C. Scale Range for Heating, Hot-Water Piping: 30 to 240 degrees F.

D. Scale Range for Steam and Steam-Condensate Piping: 30 to 240 degrees F

E. Scale Range for Air Ducts: Minus 40 to plus 160 degrees F

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one (1) of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with EPDM self-sealing rubber inserts.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one (1) of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with EPDM self-sealing rubber inserts.

C. Pressure gages at suction and discharge of each pump shall be one (1) of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 160 psi

B. Scale Range for Condenser-Water Piping: 0 to 160 psi

C. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi

D. Scale Range for Steam Piping: 0 to 200 psi

3.8 FLOWMETER SCHEDULE

A. Provide flowmeters for Chilled-Water Piping, Condenser-Water Piping, Heating Hot-Water Piping or Steam and Steam-Condensate Piping of the Orifice, Turbine, Venturi or Vortex-shedding type, as required.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Provide thermal-Energy Meters for Chilled-Water Piping, Condenser-Water Piping, Heating, Hot-Water Piping or Steam and Steam-Condensate Piping of the Impeller-turbine or Ultrasonic type, as required.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Bronze angle valves.

B. Brass ball valves.

C. Bronze ball valves.

D. Iron ball valves.

E. Iron, single-flange butterfly valves.

F. Iron, grooved-end butterfly valves.

G. High-performance butterfly valves.

H. Bronze lift check valves.

I. Bronze swing check valves.

J. Iron swing check valves.

K. Iron swing check valves with closure control.

L. Iron, grooved-end swing-check valves.

M. Iron, center-guided check valves.

N. Iron, plate-type check valves.

O. Bronze gate valves.

P. Iron gate valves.

Q. Bronze globe valves.

R. Iron globe valves.

S. Lubricated plug valves.

T. Eccentric plug valves.

U. Chainwheels.

1.3 RELATED SECTIONS

A. Division 23 HVAC piping sections for specialty valves applicable to those sections only.

B. Section 23 05 53 - Identification for HVAC Piping and Equipment: Valve tags and schedules.

1.4 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Non-rising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.5 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: For each type of valve indicated.

1.6 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.7 DELIVERY, STORAGE AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every five (5) plug valves, for each size square plug-valve head.

5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.

3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hammond Valve.
b. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American Valve, Inc.
    b. NIBCO INC.

2. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: PTFE or TFE.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 150, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Stockham Division.
    b. Kitz Corporation.

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem and Disc: Bronze.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron, bronze, or aluminum.

D. Class 150, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Crane Co.; Crane Valve Group; Stockham Division.

d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 BRASS BALL VALVES

A. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Kitz Corporation.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One (1) piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. DynaQuip Controls.
d. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
e. Hammond Valve.
f. Jamesbury; a subsidiary of Metso Automation.
g. Jomar International, LTD.
h. Kitz Corporation.
i. Legend Valve.
j. Marwin Valve; a division of Richards Industries.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Red-White Valve Corporation.
n. RuB Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

C. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
d. Hammond Valve.
e. Jamesbury; a subsidiary of Metso Automation.
f. Kitz Corporation.
g. Marwin Valve; a division of Richards Industries.
h. Milwaukee Valve Company.
i. RuB Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.

c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

D. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hammond Valve.
b. Jamesbury; a subsidiary of Metso Automation.
c. Legend Valve.
d. Marwin Valve; a division of Richards Industries.
e. Milwaukee Valve Company.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Regular.

E. Two-Piece, Regular-Port, Brass Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Jamesbury; a subsidiary of Metso Automation.
b. Marwin Valve; a division of Richards Industries.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.

c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Brass or bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

F. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Jomar International, LTD.
b. Kitz Corporation.
c. Red-White Valve Corporation.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three (3) piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

G. Three-Piece, Full-Port, Brass Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Jomar International, LTD.
b. Kitz Corporation.
c. Marwin Valve; a division of Richards Industries.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three (3) piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 BRONZE BALL VALVES

A. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig.
c. Body Design: One (1) piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Conbraco Industries, Inc.; Apollo Valves.
b. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.

b. CWP Rating: 600 psig.
c. Body Design: One (1) piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Reduced.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Crane Co.; Crane Valve Group; Crane Valves.
d. Hammond Valve.
e. Lance Valves; a division of Advanced Thermal Systems, Inc.
f. Legend Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Two-Piece, Full-Port, Bronze Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.

c. Hammond Valve.
d. Lance Valves; a division of Advanced Thermal Systems, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

E. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. DynaQuip Controls.
f. Hammond Valve.
g. Lance Valves; a division of Advanced Thermal Systems, Inc.
h. Milwaukee Valve Company.
i. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two (2) piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Conbraco Industries, Inc.; Apollo Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Hammond Valve.
    d. Milwaukee Valve Company.

2. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two (2) piece.
    e. Body Material: Bronze.
    f. Ends: Threaded.
    g. Seats: PTFE or TFE.
    h. Stem: Stainless steel.
    i. Ball: Stainless steel, vented.
    j. Port: Regular.

G. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Conbraco Industries, Inc.; Apollo Valves.
    b. DynaQuip Controls.
    c. Hammond Valve.
    d. Milwaukee Valve Company.
    e. NIBCO INC.
    f. Red-White Valve Corporation.

2. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Three (3) piece.
    e. Body Material: Bronze.
    f. Ends: Threaded.
    g. Seats: PTFE or TFE.
    h. Stem: Bronze.

i. Ball: Chrome-plated brass.
j. Port: Full.

H. Three-Piece, Full-Port, Bronze Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Conbraco Industries, Inc.; Apollo Valves.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three (3) piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.5 IRON BALL VALVES

A. Class 125, Iron Ball Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Kitz Corporation.
d. Sure Flow Equipment Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.

d. Body Material: ASTM A126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

2.6 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. NIBCO INC.
l. Norriseal; a Dover Corporation company.
m. Red-White Valve Corporation.
n. Spence Strainers International; a division of CIRCOR International.
o. Tyco Valves & Controls; a unit of Tyco Flow Control.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

B. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. Bray Controls; a division of Bray International.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    e. Crane Co.; Crane Valve Group; Jenkins Valves.
    f. Crane Co.; Crane Valve Group; Stockham Division.
    g. DeZurik Water Controls.
    h. Hammond Valve.
    i. Kitz Corporation.
    j. Milwaukee Valve Company.
    k. NIBCO INC.
    l. Norriseal; a Dover Corporation company.
    m. Red-White Valve Corporation.
    n. Spence Strainers International; a division of CIRCOR International.
    o. Tyco Valves & Controls; a unit of Tyco Flow Control.
    p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 150 psig.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
    e. Seat: NBR.
    f. Stem: One- or two-piece stainless steel.
    g. Disc: Aluminum bronze.

C. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. Bray Controls; a division of Bray International.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    e. Crane Co.; Crane Valve Group; Center Line.
    f. Crane Co.; Crane Valve Group; Stockham Division.
    g. DeZurik Water Controls.
    h. Hammond Valve.
    i. Kitz Corporation.

j. Milwaukee Valve Company.
k. Mueller Steam Specialty; a division of SPX Corporation.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Spence Strainers International; a division of CIRCOR International.
o. Sure Flow Equipment Inc.
p. Tyco Valves & Controls; a unit of Tyco Flow Control.
q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated or -coated ductile iron.

D. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Center Line.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. Mueller Steam Specialty; a division of SPX Corporation.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Spence Strainers International; a division of CIRCOR International.
o. Sure Flow Equipment Inc.
p. Tyco Valves & Controls; a unit of Tyco Flow Control.
q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.

b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated or -coated ductile iron.

E. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. Mueller Steam Specialty; a division of SPX Corporation.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Sure Flow Equipment Inc.
q. Tyco Valves & Controls; a unit of Tyco Flow Control.
r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

F. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless Steel Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. Bray Controls; a division of Bray International.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    e. Crane Co.; Crane Valve Group; Jenkins Valves.
    f. Crane Co.; Crane Valve Group; Stockham Division.
    g. DeZurik Water Controls.
    h. Hammond Valve.
    i. Kitz Corporation.
    j. Milwaukee Valve Company.
    k. Mueller Steam Specialty; a division of SPX Corporation.
    l. NIBCO INC.
    m. Norriseal; a Dover Corporation company.
    n. Red-White Valve Corporation.
    o. Spence Strainers International; a division of CIRCOR International.
    p. Sure Flow Equipment Inc.
    q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 150 psig.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
    e. Seat: NBR.
    f. Stem: One- or two-piece stainless steel.
    g. Disc: Stainless steel.

G. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. Conbraco Industries, Inc.; Apollo Valves.
    c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    d. Crane Co.; Crane Valve Group; Jenkins Valves.
    e. Crane Co.; Crane Valve Group; Stockham Division.
    f. DeZurik Water Controls.
    g. Flo Fab Inc.

h. Hammond Valve.
i. Kitz Corporation.
j. Legend Valve.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

H. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Flo Fab Inc.
h. Hammond Valve.
i. Kitz Corporation.
j. Legend Valve.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

I. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Center Line.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.
p. Spence Strainers International; a division of CIRCOR International.
q. Sure Flow Equipment Inc.
r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated or -coated ductile iron.

J. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. American Valve, Inc.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    e. Crane Co.; Crane Valve Group; Center Line.
    f. Crane Co.; Crane Valve Group; Stockham Division.
    g. DeZurik Water Controls.
    h. Flo Fab Inc.
    i. Hammond Valve.
    j. Kitz Corporation.
    k. Legend Valve.
    l. Milwaukee Valve Company.
    m. Mueller Steam Specialty; a division of SPX Corporation.
    n. NIBCO INC.
    o. Norriseal; a Dover Corporation company.
    p. Spence Strainers International; a division of CIRCOR International.
    q. Sure Flow Equipment Inc.
    r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-67, Type I.
    b. CWP Rating: 200 psig.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
    e. Seat: NBR.
    f. Stem: One- or two-piece stainless steel.
    g. Disc: Nickel-plated or -coated ductile iron.

K. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless Steel Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    b. American Valve, Inc.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
    e. Crane Co.; Crane Valve Group; Jenkins Valves.
    f. Crane Co.; Crane Valve Group; Stockham Division.

g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.
p. Red-White Valve Corporation.
q. Spence Strainers International; a division of CIRCOR International.
r. Sure Flow Equipment Inc.
s. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

L. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless Steel Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.

p. Red-White Valve Corporation.
q. Spence Strainers International; a division of CIRCOR International.
r. Sure Flow Equipment Inc.
s. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

2.7 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Kennedy Valve; a division of McWane, Inc.
b. Shurjoint Piping Products.
c. Tyco Fire Products LP; Grinnell Mechanical Products.
d. Victaulic Company.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 175 psig.
c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Anvil International, Inc.
b. Kennedy Valve; a division of McWane, Inc.

c. Mueller Steam Specialty; a division of SPX Corporation.
d. NIBCO INC.
e. Shurjoint Piping Products.
f. Tyco Fire Products LP; Grinnell Mechanical Products.
g. Victaulic Company.

2. Description:

a. Standard: MSS SP-67, Type I.
b. NPS 8 and Smaller CWP Rating: 300 psig.
c. NPS 10 and Larger CWP Rating: 200 psig.
d. Body Material: Coated, ductile iron.
e. Stem: Two-piece stainless steel.
f. Disc: Coated, ductile iron.
g. Seal: EPDM.

2.8 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 degrees F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
e. Seat: Reinforced PTFE or metal.

f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 degrees F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.9 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Flo Fab Inc.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. Mueller Steam Specialty; a division of SPX Corporation.
f. NIBCO INC.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: NBR, PTFE, or TFE.

2.10 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.

d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. American Valve, Inc.
    b. Crane Co.; Crane Valve Group; Crane Valves.
    c. Crane Co.; Crane Valve Group; Jenkins Valves.
    d. Crane Co.; Crane Valve Group; Stockham Division.
    e. Kitz Corporation.
    f. Milwaukee Valve Company.
    g. NIBCO INC.
    h. Red-White Valve Corporation.
    i. Zy-Tech Global Industries, Inc.

2. Description:

    a. Standard: MSS SP-80, Type 3.
    b. CWP Rating: 300 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B62, bronze.
    e. Ends: Threaded.
    f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Hammond Valve.
    d. Milwaukee Valve Company.
    e. NIBCO INC.
    f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-80, Type 4.
    b. CWP Rating: 300 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B62, bronze.
    e. Ends: Threaded.
    f. Disc: PTFE or TFE.

2.11 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Legend Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Sure Flow Equipment Inc.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.

d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE or TFE.
k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.12 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. NIBCO INC.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and weight.

2.13 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Anvil International, Inc.
b. Shurjoint Piping Products.

c. Tyco Fire Products LP; Grinnell Mechanical Products.
d. Victaulic Company.

2. Description:

a. CWP Rating: 300 psig.
b. Body Material: ASTM A536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.14 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Anvil International, Inc.
b. APCO Willamette Valve and Primer Corporation.
c. Crispin Valve.
d. DFT Inc.
e. Flo Fab Inc.
f. GA Industries, Inc.
g. Hammond Valve.
h. Metraflex, Inc.
i. Milwaukee Valve Company.
j. Mueller Steam Specialty; a division of SPX Corporation.
k. NIBCO INC.
l. Spence Strainers International; a division of CIRCOR International.
m. Sure Flow Equipment Inc.
n. Val-Matic Valve & Manufacturing Corp.
o. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Compact wafer.
f. Seat: Bronze.

B. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Flomatic Corporation.
    e. Hammond Valve.
    f. Metraflex, Inc.
    g. Milwaukee Valve Company.
    h. Mueller Steam Specialty; a division of SPX Corporation.
    i. NIBCO INC.
    j. Spence Strainers International; a division of CIRCOR International.
    k. Sure Flow Equipment Inc.
    l. Val-Matic Valve & Manufacturing Corp.
    m. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: Bronze.

C. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
    c. NPS 14 to NPS 24, CWP Rating: 250 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Compact wafer.
    f. Seat: Bronze.

D. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
    c. NPS 14 to NPS 24, CWP Rating: 250 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: Bronze.

E. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Metraflex, Inc.
    g. Milwaukee Valve Company.
    h. NIBCO INC.
    i. Sure Flow Equipment Inc.
    j. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Compact wafer, spring loaded.
    f. Seat: Bronze.

F. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Flomatic Corporation.
    e. Hammond Valve.
    f. Metraflex, Inc.
    g. Milwaukee Valve Company.
    h. Mueller Steam Specialty; a division of SPX Corporation.
    i. NIBCO INC.
    j. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: Bronze.

G. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 400 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Compact wafer, spring loaded.
    f. Seat: Bronze.

H. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 400 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: Bronze.

I. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Milwaukee Valve Company.
    g. NIBCO INC.
    h. Spence Strainers International; a division of CIRCOR International.
    i. Sure Flow Equipment Inc.
    j. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Compact wafer.
    f. Seat: EPDM or NBR.

J. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Anvil International, Inc.
    b. APCO Willamette Valve and Primer Corporation.
    c. Crispin Valve.
    d. DFT Inc.
    e. GA Industries, Inc.
    f. Hammond Valve.
    g. Milwaukee Valve Company.
    h. NIBCO INC.
    i. Sure Flow Equipment Inc.
    j. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: EPDM or NBR.

K. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
    c. NPS 14 to NPS 24, CWP Rating: 250 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Compact wafer.
    f. Seat: EPDM or NBR.

L. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
    c. NPS 14 to NPS 24, CWP Rating: 250 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: EPDM or NBR.

M. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Milwaukee Valve Company.
    g. NIBCO INC.
    h. Sure Flow Equipment Inc.
    i. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Compact wafer, spring loaded.
    f. Seat: EPDM or NBR.

N. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. DFT Inc.
    d. Hammond Valve.
    e. Milwaukee Valve Company.
    f. NIBCO INC.
    g. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A126, gray iron.
    e. Style: Globe, spring loaded.
    f. Ends: Flanged.
    g. Seat: EPDM or NBR.

O. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crispin Valve.
    c. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-125.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 400 psig.
    d. Body Material: ASTM A395 or ASTM A536, ductile iron.
    e. Style: Compact wafer, spring loaded.
    f. Seat: EPDM or NBR.

P. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. Val-Matic Valve & Manufacturing Corp.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Material: ASTM A395 or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM or NBR.

2.15 IRON, PLATE-TYPE CHECK VALVES

A. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Flomatic Corporation.
d. Mueller Steam Specialty; a division of SPX Corporation.

2. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A126, gray iron.
f. Seat: Bronze.

B. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Mueller Steam Specialty; a division of SPX Corporation.
d. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: API 594.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
    c. NPS 14 to NPS 24, CWP Rating: 250 psig.
    d. Body Design: Wafer, spring-loaded plates.
    e. Body Material: ASTM A395 or ASTM A536, ductile iron.
    f. Seat: Bronze.

C. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crane Co.; Crane Valve Group; Crane Valves.

2. Description:

    a. Standard: API 594.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Design: Wafer, spring-loaded plates.
    e. Body Material: ASTM A126, gray iron.
    f. Seat: Bronze.

D. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Crane Co.; Crane Valve Group; Crane Valves.
    c. Mueller Steam Specialty; a division of SPX Corporation.
    d. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: API 594.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 400 psig.
    d. Body Design: Wafer, spring-loaded plates.
    e. Body Material: ASTM A395 or ASTM A536, ductile iron.
    f. Seat: Bronze.

E. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Flo Fab Inc.
    b. Sure Flow Equipment Inc.

2. Description:

    a. Standard: API 594.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Design: Wafer, spring-loaded plate.
    e. Body Material: ASTM A126, gray iron.
    f. Seat: EPDM or NBR.

F. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. APCO Willamette Valve and Primer Corporation.
    b. Cooper Cameron Valves TVB Techno.
    c. Crane Co.; Crane Valve Group; Crane Valves.
    d. Crane Co.; Crane Valve Group; Stockham Division.
    e. NIBCO INC.
    f. Spence Strainers International; a division of CIRCOR International.
    g. Sure Flow Equipment Inc.
    h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: API 594.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Design: Wafer, spring-loaded plates.
    e. Body Material: ASTM A126, gray iron.
    f. Seat: EPDM or NBR.

G. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Val-Matic Valve & Manufacturing Corp.

2. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A395 or ASTM A536, ductile iron.
f. Seat: EPDM or NBR.

H. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Sure Flow Equipment Inc.

2. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Wafer, spring-loaded plate.
e. Body Material: ASTM A126, gray iron.
f. Seat: EPDM or NBR.

I. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Sure Flow Equipment Inc.

2. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Wafer, spring-loaded plates.

e. Body Material: ASTM A126, gray iron.
f. Seat: EPDM or NBR.

J. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. APCO Willamette Valve and Primer Corporation.
b. Val-Matic Valve & Manufacturing Corp.

2. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A395 or ASTM A536, ductile iron.
f. Seat: EPDM or NBR.

2.16 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.

c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 150, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hammond Valve.
b. Kitz Corporation.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Powell Valves.

f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

D. Class 150, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.17 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Crane Co.; Crane Valve Group; Stockham Division.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Kitz Corporation.
    g. Legend Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.
    j. Powell Valves.
    k. Red-White Valve Corporation.
    l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    m. Zy-Tech Global Industries, Inc.

2. Description:

    a. Standard: MSS SP-70, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A126, gray iron with bolted bonnet.
    e. Ends: Flanged.
    f. Trim: Bronze.
    g. Disc: Solid wedge.
    h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Crane Co.; Crane Valve Group; Stockham Division.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Kitz Corporation.
    g. Legend Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.
    j. Powell Valves.
    k. Red-White Valve Corporation.
    l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

m. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. NIBCO INC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-70, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A126, gray iron with bolted bonnet.
    e. Ends: Flanged.
    f. Trim: Bronze.
    g. Disc: Solid wedge.
    h. Packing and Gasket: Asbestos free.

2.18 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Stockham Division.
    c. Hammond Valve.
    d. Kitz Corporation.
    e. Milwaukee Valve Company.
    f. NIBCO INC.
    g. Powell Valves.
    h. Red-White Valve Corporation.
    i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    j. Zy-Tech Global Industries, Inc.

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded or solder joint.
    e. Stem and Disc: Bronze.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. NIBCO INC.
d. Red-White Valve Corporation.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.19 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Powell Valves.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig.

c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

2.20 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Nordstrom Valves, Inc.

2. Description:

a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Venturi.
f. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Nordstrom Valves, Inc.

2. Description:

a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Venturi.
f. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Homestead Valve; a division of Olson Technologies, Inc.
    b. Milliken Valve Company.
    c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:

    a. Standard: MSS SP-78, Type IV.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
    e. Pattern: Venturi.
    f. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Homestead Valve; a division of Olson Technologies, Inc.
    b. Milliken Valve Company.
    c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:

    a. Standard: MSS SP-78, Type IV.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
    e. Pattern: Venturi.
    f. Plug: Cast iron or bronze with sealant groove.

E. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Nordstrom Valves, Inc.

2. Description:

a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Venturi.
f. Plug: Cast iron or bronze with sealant groove.

F. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Nordstrom Valves, Inc.

2. Description:

a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Venturi.
f. Plug: Cast iron or bronze with sealant groove.

G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Homestead Valve; a division of Olson Technologies, Inc.
b. Milliken Valve Company.
c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A48 or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Venturi.
f. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Homestead Valve; a division of Olson Technologies, Inc.
    b. Milliken Valve Company.
    c. R & M Energy Systems, a unit of Robbins & Myers, Inc.

2. Description:

    a. Standard: MSS SP-78, Type IV.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A48 or ASTM A126, Grade 40 cast iron with lubrication-sealing system.
    e. Pattern: Venturi.
    f. Plug: Cast iron or bronze with sealant groove.

2.21 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Clow Valve Co.; a division of McWane, Inc.
    b. DeZurik Water Controls.
    c. Homestead Valve; a division of Olson Technologies, Inc.
    d. M&H Valve Company; a division of McWane, Inc.
    e. Milliken Valve Company.
    f. Henry Pratt Company.
    g. Val-Matic Valve & Manufacturing Corp.

2. Description:

    a. Standard: MSS SP-108.
    b. CWP Rating: 175 psig minimum.
    c. Body and Plug: ASTM A48, gray iron; ASTM A126, gray iron; or ASTM A536, ductile iron.
    d. Bearings: Oil-impregnated bronze or stainless steel.
    e. Ends: Flanged.
    f. Stem-Seal Packing: Asbestos free.
    g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

2.22 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

2. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc coating.

3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly, gate, globe and plug valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly, or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service except Steam: Globe or ball valves.
4. Throttling Service, Steam: Globe valves.
5. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125 bronze disc.
3. Ball Valves: One (1) or Two (2) piece, full port, brass or bronze with brass, bronze or stainless steel trim.
4. Bronze Swing Check Valves: Class 125, bronze disc.
5. Bronze Gate Valves: Class 125, NRS, bronze.
6. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, ductile-iron disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, ductile-iron disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. High-Performance Butterfly Valves: Class 150, single flange.
6. Iron Swing Check Valves: Class 125, metal seats.
7. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
8. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
9. Iron, Center-Guided Check Valves: Class 125, globe, metal seat.
10. Iron, Plate-Type Check Valves: Class 125; single plate; metal seat.
11. Iron Gate Valves: Class 125, OS&Y.
12. Iron Globe Valves: Class 125.
13. Lubricated Plug Valves: Class 125, cylindrical, flanged.
14. Eccentric Plug Valves: 175 CWP, resilient seating.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125, bronze disc.
3. Ball Valves: One (1) or Two (2) piece, full port, brass or bronze with brass, bronze or stainless steel trim.
4. Bronze Swing Check Valves: Class 125, bronze disc.
5. Bronze Gate Valves: Class 125, NRS.
6. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, ductile-iron disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, ductile-iron disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. High-Performance Butterfly Valves: Class 150, single flange.
6. Iron Swing Check Valves: Class 125, metal seats.
7. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
8. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
9. Iron, Center-Guided Check Valves, NPS 2-1/2 to NPS 24: Class 125, metal seat.
10. Iron, Plate-Type Check Valves: Class 125; single plate; metal seat.
11. Iron Gate Valves: Class 125, OS&Y.
12. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 125.
13. Lubricated Plug Valves: Class 125, cylindrical, flanged.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125, bronze disc.
3. Ball Valves: One (1) or Two (2) piece, full port, brass or bronze with brass, bronze or stainless steel trim.
4. Bronze Swing Check Valves: Class 125, bronze disc.
5. Bronze Gate Valves: Class 125, NRS.
6. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150 & Class 250.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
4. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
5. High-Performance Butterfly Valves: Class 300, single flange.
6. Iron Swing Check Valves: Class 125 & Class 250, metal seats.
7. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125 & Class 250, lever and spring.
8. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
9. Iron, Center-Guided Check Valves: Class 125 & Class 250, globe, metal seat.
10. Iron, Plate-Type Check Valves: Class 125 & Class 250; single plate; metal seat.
11. Iron Gate Valves: Class 125 & Class 250, OS&Y.
12. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 125 & Class 250.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 125, bronze disc.
2. Ball Valves: One (1) or Two (2) piece, full port, brass or bronze with brass, bronze or stainless steel trim.
3. Bronze Swing Check Valves: Class 125, bronze disc.
4. Bronze Gate Valves: Class 125, NRS.
5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
2. High-Performance Butterfly Valves: Class 150, single flange.
3. Iron Swing Check Valves: Class 125, metal seats.
4. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
5. Iron Gate Valves: Class 125, OS&Y.
6. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 125.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: One or Two piece, full port, brass or bronze with brass, bronze or stainless steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.

4. Bronze Gate Valves: Class 150, NRS, bronze.
5. Globe Valves: Class 150, bronze, bronze disc.

B. Pipe Sizes NPS 2-1/2 and Larger:

1. Ball Valves, NPS 2-1/2 to NPS 10: Class 150, iron.
2. High-Performance Butterfly Valves: Class 150, single flange.
3. Iron Swing Check Valves: Class 250, metal seats.
4. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
5. Iron Gate Valves: Class 250, OS&Y.
6. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 250.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: One or Two piece, full port, brass or bronze with brass, bronze or stainless steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, NRS, bronze.
5. Globe Valves: Class 150, bronze, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Ball Valves, NPS 2-1/2 to NPS 10: Class 150, iron.
2. High-Performance Butterfly Valves: Class 150, single flange.
3. Iron Swing Check Valves: Class 250, metal seats.
4. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
5. Iron Gate Valves: Class 250, OS&Y.
6. Iron Globe Valves, NPS 2-1/2 to NPS 12: Class 250.
7. Lubricated Plug Valves: Class 250, cylindrical, flanged.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Metal pipe hangers and supports.

B. Trapeze pipe hangers.

C. Fiberglass pipe hangers.

D. Metal framing systems.

E. Fiberglass strut systems.

F. Thermal-hanger shield inserts.

G. Fastener systems.

H. Pipe stands.

I. Equipment supports.

J. Rooftop Duct and Piping Supports

1.3 RELATED SECTIONS

A. Section 05 50 00 - Metal Fabrications: Structural steel shapes and plates for trapeze hangers for pipe and equipment supports.

B. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping: Pipe guides and anchors.

C. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment: Vibration isolation devices.

D. Section 23 31 13 - Metal Ducts: Duct hangers and supports.

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers, rooftop ductwork and piping support systems, and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design supports for rooftop ductwork and piping supports, including sub-framing, support rail, etc… capable of supporting combined weight of supported systems, system contents, and test water.
3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
4. Design seismic-restraint hangers and supports for piping and equipment.

C. HANGERS FOR PIPES, DUCTS, CONDUITS, PANELS, TRANSFORMERS, MECHANICAL AND PLUMBING EQUIPMENT, ETC. ARE INTENDED TO BE SUPPORTED BY UNI-STRUTS OR CLAMPS OR SIMILAR DEVICES ATTACHED TO THE STRUCTURAL STEEL AND JOIST PANEL POINTS. IT IS NOT INTENDED FOR THESE HANGERS TO BE PRIMARILY SUPPORTED FROM THE FLOOR AND ROOF DECKS. DO NOT INSTALL HANGERS DIRECTLY TO THE ROOF DECK. REFER TO THE STEEL DECKING SPECIFICATION SECTION 05 31 00 FOR REQUIREMENTS PERTAINING TO HANGERS SUPPORTED BY THE FLOOR DECK.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include product data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

E. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.

a. Hanger Rods and fittings: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.

a. Hanger Rods and fittings: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.

c. Flex-Strut Inc.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut Corporation; Tyco International, Ltd.
g. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Electroplated zinc, Hot-dipped galvanized, Mill galvanized, In-line, hot galvanized or Mechanically-deposited zinc.
8. Paint Coating: Vinyl or Vinyl alkyd.
9. Plastic Coating: PVC or Polyurethane.

2.5 FIBERGLASS STRUT SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Allied Tube & Conduit.
2. Champion Fiberglass, Inc.
3. Cooper B-Line, Inc.
4. SEASAFE, INC.; a Gibraltar Industries Company.

B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.

1. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.6 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.

4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C533, Type I calcium silicate with 100-psig or ASTM C552, Type II cellular glass with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend two (2) inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Not approved for use.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.8 PIPE STAND FABRICATION

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

2. Base: Plastic.
3. Vertical Members: Two (2) or more cadmium-plated-steel or stainless steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless steel rod with plastic or stainless steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One (1) or more; plastic.
3. Vertical Members: Two (2) or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.10 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, non-corrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:

1. Powder-actuated fasteners are not acceptable for use.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 for curbs.

I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded structural steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 4" and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

P. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048-inch thick.

    b. NPS 4: 12 inches long and 0.06-inch thick.

    c. NPS 5 and NPS 6: 18 inches long and 0.06-inch thick.

    d. NPS 8 to NPS 14: 24 inches long and 0.075-inch thick.

    e. NPS 16 to NPS 24: 24 inches long and 0.105-inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 degrees F, pipes NPS 4 to NPS 24, requiring up to four (4) inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to four (4) inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two (2) rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to six (6) inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 degrees F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 degrees F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one (1) of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one (1) support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two (2) vertical-type supports and one (1) trapeze member.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system sections.

R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. This Section includes heat tracing with self-regulating, parallel resistance electric heating cables.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 16 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 03 - Building Commissioning Requirements.

F. Section 23 08 00 - Commissioning of HVAC.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company
2. Delta-Therm Corporation
3. Raychem; a division of Tyco Thermal Controls

B. Description: Provide a complete UL listed, CSA certified, or FM approved system of heating cables, components, and controls to prevent pipes from freezing.

C. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: Tinned-copper, and polyolefin outer jacket with UV inhibitor.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. Capacities and Characteristics:

1. Maximum Heat Output: 8 W/ft.
2. Volts: 120.
3. Phase: 1
4. Hertz: 60

I. CONTROLS

1. Thermostat Control – Line Sensing: Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
2. Corrosion-resistant, waterproof control enclosure.

J. ACCESSORIES

1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer. Connection systems that require cutting or stripping to expose buswire, or that use crimps or terminal blocks will not be accepted.
2. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

    a. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
    b. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1- 1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Division 23 Section "HVAC Insulation."

E. Install warning tape on 10 foot centers on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Protect installed heating cables, including non-heating leads, from damage.

H. For heat tracing using line sensing, install temperature sensor in an area that is representative of conditions along entire length of pipe.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.
2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Elastomeric isolation pads.

B. Elastomeric isolation mounts.

C. Restrained elastomeric isolation mounts.

D. Open-spring isolators.

E. Housed-spring isolators.

F. Restrained-spring isolators.

G. Housed-restrained-spring isolators.

H. Pipe-riser resilient supports.

I. Resilient pipe guides.

J. Air-spring isolators.

K. Restrained-air-spring isolators.

L. Elastomeric hangers.

M. Spring hangers.

N. Snubbers.

O. Restraint channel bracings.

P. Restraint cables.

Q. Seismic-restraint accessories.

R. Mechanical anchor bolts.

S. Adhesive anchor bolts.

T. Vibration isolation equipment bases.

U. Restrained isolation roof-curb rails.

1.3 RELATED REQUIREMENTS

A. Section 21 05 48- Vibration and Seismic Controls for Fire Suppression:Devices for fire-suppression equipment and systems.

B. Section 22 05 48- Vibration and Seismic Controls for Plumbing:Devices for plumbing equipment and systems.

C. Section 01 91 03 - Building Commissioning Requirements.

D. Section 23 08 00 – Commissioning of HVAC.

1.4 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.5 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

C. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

D. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other sections for equipment mounted outdoors.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.

4. Seismic- and Wind-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

C. Qualification Data: For professional engineer.

D. Welding certificates.

E. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

F. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on

calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: Refer to the Architectural Code Compliance drawings.
2. Building Classification Category: Refer to the Architectural Code Compliance drawings.
3. Minimum 10 lb/sq ft multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined on the Structural drawings.

2. Assigned Seismic Use Group or Building Category as Defined on the Structural drawings.

    a. Component Importance Factor: Refer to ASCE 7-02.
    b. Component Response Modification Factor: Refer to ASCE 7-02.
    c. Component Amplification Factor: Refer to ASCE 7-02.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): Refer to the Structural drawings.
4. Design Spectral Response Acceleration at 1.0-Second Period: Refer to the Structural drawings.

5. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES, or an agency acceptable to authorities having jurisdiction.

    a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they are subjected.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibro-Acoustics
    g. Vibration Eliminator Co., Inc.
    h. Vibration Isolation.
    i. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.

4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth, Ribbed or Waffle pattern.

6. Infused nonwoven cotton or synthetic fibers.

7. Load-bearing metal plates adhered to pads.

8. Sandwich-Core Material: Resilient and elastomeric.

    a. Surface Pattern: Smooth pattern.
    b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibro-Acoustics
    g. Vibration Eliminator Co., Inc.
    h. Vibration Isolation.
    i. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibro-Acoustics
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with seismic restraints containing two (2) separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Ace Mountings Co., Inc.

b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibro-Acoustics
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation.
i. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibro-Acoustics
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation.
i. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt, or threaded mounting holes and internal leveling device and elastomeric pad.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Ace Mountings Co., Inc.
    b. California Dynamics Corporation.
    c. Isolation Technology, Inc.
    d. Kinetics Noise Control, Inc.
    e. Mason Industries, Inc.
    f. Vibro-Acoustics
    g. Vibration Eliminator Co., Inc.
    h. Vibration Isolation.
    i. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with [threaded mounting holes] [elastomeric pad].
    c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibro-Acoustics
g. Vibration Eliminator Co., Inc.
h. Vibration Isolation.
i. Vibration Mountings & Controls, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two (2) steel tubes separated by a minimum 1/2-inch thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two (2) steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Firestone Industrial Products Company.
b. Mason Industries, Inc.

2. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
3. Maximum Natural Frequency: 3 Hz.
4. Operating Pressure Range: 25 to 100 psig.
5. Burst Pressure: At least three (3) times manufacturer's published maximum operating pressure.

6. Tank valves.

2.12 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Firestone Industrial Products Company.
b. Mason Industries, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.

b. Top plate with [threaded mounting holes] [elastomeric pad].
c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
9. Maximum Natural Frequency: Three (3) Hz.
10. Operating Pressure Range: 25 to 100 psig.
11. Burst Pressure: At least three (3) times manufacturer's published maximum operating pressure.
12. Tank valves.

2.13 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: [Insert drawing designation].

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibro-Acoustics
g. Vibration Eliminator Co., Inc.
h. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.14 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: [Insert drawing designation].

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Kinetics Noise Control, Inc.
   d. Mason Industries, Inc.
   e. Vibro-Acoustics
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.15 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibro-Acoustics
4. Vibration Mountings & Controls, Inc.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

2.16 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper B-Line, Inc.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one (1) end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.17 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.
3. Vibro-Acoustics
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A603 galvanized or ASTM A492 stainlesssteel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two (2) clamping bolts for cable engagement.

2.18 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper B-Line, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to [rigid channel bracings] [and] [restraint cables].

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.19 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements,provide products by one (1) of the following:

1. Cooper B-Line, Inc.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.20 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.21 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. California Dynamics Corporation.
2. Kinetics Noise Control.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

a. Include supports for suction and discharge elbows for pumps.
b. Include supports for suction diffusers for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.
b. Include supports for suction diffusers for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.
b. Include supports for suction diffusers for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.22 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements,provide products by one (1) of the following:

1. Ace Mountings Co., Inc.
2. California Dynamics Corporation.
3. Kinetics Noise Control.
4. Mason Industries, Inc.
5. Thybar Corporation.

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismicand wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of two (2) inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4-inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 and Section 03 30 53.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 07 72 00 for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom

of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one (1) supporting the connections as they approach equipment. Comply with requirements in Section 23 21 13 for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven (7) days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four (4) of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 AIR-SPRING ISOLATOR INSTALLATION

A. Independent Isolator Installation:

1. Install tank valve into each air isolator.
2. Inflate each isolator to heightandpressure as recommended by the isolator manufacturer.

3.8 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 and Section 03 30 53.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Equipment labels.

B. Warning signs and labels.

C. Pipe labels.

D. Duct labels.

E. Stencils.

F. Valve tags.

G. Warning tags.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Samples: For color, letter style, and graphic representation required for each identification material and device.

D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

E. Valve numbering scheme.

F. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the specification section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the specification section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 degrees F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4-inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 09 91 00.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1**,** on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Chilled-Water Piping:

a. Background Color: Blue.
b. Letter Color: Black.

2. Condenser-Water Piping:

a. Background Color: White.
b. Letter Color: Black.

3. Heating Water Piping:

a. Background Color: Red.
b. Letter Color: Black.

4. Refrigerant Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

5. Low-Pressure Steam Piping:

a. Background Color: Red.
b. Letter Color: White.

6. High-Pressure Steam Piping:

a. Background Color: White.
b. Letter Color: Red.

7. Steam Condensate Piping:

a. Background Color: White.
b. Letter Color: Blue.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering

larger than one (1) inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Chilled Water: 1-1/2 inches, square.
b. Condenser Water: 1-1/2 inches, square.
c. Refrigerant: 1-1/2 inches, square.
d. Hot Water: 1-1/2 inches, square.
e. Gas: 1-1/2 inches, square.
f. Low-Pressure Steam: 2-inches,square.
g. High-Pressure Steam: 2-inches, square.
h. Steam Condensate: 2-inches, square.

2. Valve-Tag Color:

a. Chilled Water: Natural.
b. Condenser Water: Natural.
c. Refrigerant: Natural.
d. Hot Water: Natural.
e. Gas: Natural.
f. Low-Pressure Steam: Natural.
g. High-Pressure Steam: Natural.
h. Steam Condensate: Natural.

3. Letter Color:

a. Chilled Water: Black.
b. Condenser Water: Black.
c. Refrigerant: Black.
d. Hot Water: Black.
e. Gas: Black.

f. Low-Pressure Steam: Black.
g. High-Pressure Steam: Black.
h. Steam Condensate: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Balancing Air Systems:

1. Constant-volume air systems.
2. Variable-air-volume systems.

B. Balancing Hydronic Piping Systems:

1. Constant-flow hydronic systems.
2. Variable-flow hydronic systems.
3. Primary-secondary hydronic systems.

1.3 RELATED SECTIONS

A. Section 01 91 13 - General Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

1.4 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.5 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this project's TAB team members meet the qualifications specified in "Quality Assurance" article.

C. Contract Documents Examination Report: Within 15 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

D. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" article.

E. Certified TAB reports.

F. Sample report forms.

G. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by TABB as a TAB technician.

B. TAB Conference: Meet with Architect, Construction Manager & Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven (7) days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Architect & Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.7 COORDINATION

A. Notice: Provide seven (7) days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual sections have been performed.

H. Examine test reports specified in individual system and equipment sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 00.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 23 31 13.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Architect & Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.

2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus five (5) percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

    a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect & Commissioning Authority and comply with requirements in Section 23 21 23.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.12 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator to within specified tolerances of indicated flow with all pumps operating. With only one (1) chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
5. Capacity: Calculate in tons of cooling.
6. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.16 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. The contractor shall perform all work of this section before construction begins. A baseline performance of the existing systems, which will be impacted by the renovation work, shall be documented and available for baseline reference to be used when final T&B is performed.

B. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

C. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

D. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than five (5) percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is five (5) percent or less, equipment adjustments are not required.

4. Balance each air outlet.

E. Submit final T&B report to the Office of State Building Inspector (OSBI).

3.17 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.18 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance; do not include shop drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

    a. Total air flow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Filter static-pressure differential in inches wg.
    f. Preheat-coil static-pressure differential in inches wg.
    g. Cooling-coil static-pressure differential in inches wg.
    h. Heating-coil static-pressure differential in inches wg.
    i. Outdoor airflow in cfm.
    j. Return airflow in cfm.
    k. Outdoor-air damper position.
    l. Return-air damper position.
    m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

    a. System identification.
    b. Location.
    c. Coil type.
    d. Number of rows.
    e. Fin spacing in fins per inch o.c.
    f. Make and model number.
    g. Face area in sq ft.
    h. Tube size in NPS.
    i. Tube and fin materials.
    j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

    a. Air flow rate in cfm.
    b. Average face velocity in fpm.
    c. Air pressure drop in inches wg.
    d. Outdoor-air, wet- and dry-bulb temperatures in degrees F.
    e. Return-air, wet- and dry-bulb temperatures in degrees F.
    f. Entering-air, wet- and dry-bulb temperatures in degrees F.
    g. Leaving-air, wet- and dry-bulb temperatures in degrees F.
    h. Water flow rate in gpm.
    i. Water pressure differential in feet of head or psig.
    j. Entering-water temperature in degrees F.
    k. Leaving-water temperature in degrees F.
    l. Refrigerant expansion valve and refrigerant types.
    m. Refrigerant suction pressure in psig.
    n. Refrigerant suction temperature in degrees F.
    o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Fuel type in input data.
    g. Output capacity in Btu/h.
    h. Ignition type.
    i. Burner-control types.
    j. Motor horsepower and rpm.
    k. Motor volts, phase, and hertz.

l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in degrees F.
c. Leaving-air temperature in degrees F.
d. Air temperature differential in degrees F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in degrees F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm.
i. Face area in sq ft.
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Air flow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in degrees F.
e. Leaving-air temperature in degrees F.
f. Voltage at each connection.

g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in degrees F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq ft.
g. Indicated air flow rate in cfm.

h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq ft.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Air velocity in fpm.
c. Preliminary air flow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final air flow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in degrees F.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm.
b. Entering-water temperature in degrees F.
c. Leaving-water temperature in degrees F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in degrees F.

f. Leaving-air temperature in degrees F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.20 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least five (5) percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect & Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect & Commissioning Authority.
3. Architect & Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.21 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

3.22 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 13 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 13 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 13 and 23 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Insulation Materials:

1. Calcium silicate.
2. Cellular glass.
3. Flexible elastomeric.
4. Mineral fiber.

B. Fire-rated insulation systems.

C. Insulating cements.

D. Adhesives.

E. Mastics.

F. Lagging adhesives.

G. Sealants.

H. Factory-applied jackets.

I. Field-applied fabric-reinforcing mesh.

J. Field-applied cloths.

K. Field-applied jackets.

L. Tapes.

M. Securements.

N. Corner angles.

1.3 RELATED SECTIONS

A. Section 22 07 00 - Plumbing - Insulation.

B. Section 23 31 13 - Metal Ducts: Duct liners.

1.4 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
b. Sheet Form Insulation Materials: 12 inches square.
c. Jacket Materials for Pipe: 12 inches long by NPS 2.
d. Sheet Jacket Materials: 12 inches square.
e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Qualification Data: For qualified Installer.

F. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Insulation shall be in accordance with the 2012 International Energy Conservation Code (IECC)

C. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Section 23 05 29.

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Johns Manville Industrial Insulation Group (The); Thermo-12 Gold.
    b. IIG Industrial Insulation Group, LLC.
    c. Promat Inc.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Cell-U-Foam Corporation; Ultra-CUF.
    b. K-Flex USA.
    c. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Aeroflex USA Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Duct Wrap.
    d. Manson Insulation Inc.; Alley Wrap.
    e. Owens Corning; All-Service Duct Wrap.

J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Johns Manville; HTB 23 Spin-Glas.
    b. Knauf Insulation; ET Batt 1000.
    c. Owens Corning; High Temperature Flexible Batt Insulations.

K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. CertainTeed Corp.; Commercial Board.
    b. Fibrex Insulations Inc.; FBX.
    c. Johns Manville; 800 Series Spin-Glas.
    d. Knauf Insulation; Insulation Board.
    e. Manson Insulation Inc.; AK Board.
    f. Owens Corning; Fiberglas 700 Series.

L. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Fibrex Insulations Inc.; FBX.
    b. Johns Manville; 1000 Series Spin-Glas.
    c. Owens Corning; High Temperature Industrial Board Insulations.
    d. Rock Wool Manufacturing Company; Delta Board.
    e. Roxul Inc.; Roxul RW.
    f. Thermafiber; Thermafiber Industrial Felt.

M. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000 Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.
    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 Degree F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.
3. Type II, 1200 Degree F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.

N. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu ft or more. Thermal conductivity (k-value) at 100 degrees F is 0.29 Btu x in/h x sq ft x degrees F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 degrees F. Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

B. Fire-Rated Blanket: Lightweight, non-asbestos, high-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. CertainTeed Corp.; FlameChek.
b. Johns Manville; Firetemp Wrap.
c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
d. Thermal Ceramics; FireMaster Duct Wrap.
e. 3M; Fire Barrier Wrap Products.
f. Unifrax Corporation; FyreWrap.
g. Vesuvius; PYROSCAT FP FASTR Duct Wrap.

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Insulco, Division of MFS, Inc.; Triple I.
b. Industrial Insulation Group, LLC.
c. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. P. K. Insulation Mfg. Co., Inc.; Thermal-V-Kote.
b. Thermal Ceramics; Therm-O-Seal Insulating Cement.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Insulco, Division of MFS, Inc.; SmoothKote.
b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
c. Rock Wool Manufacturing Company; Delta One Shot.

2.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range to match application.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-97.
b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
c. Marathon Industries, Inc.; 290.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.
c. Henkel Corporation.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-82.
    b. Foster Products Corporation, H. B. Fuller Company; 85-20.
    c. ITW TACC, Division of Illinois Tool Works; S-90/80.
    d. Marathon Industries, Inc.; 225.
    e. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Dow Chemical Company (The); 739, Dow Silicone.
    b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Speedline Vinyl Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 100 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; CP-35.
    b. Foster Products Corporation, H. B. Fuller Company; 30-90.
    c. ITW TACC, Division of Illinois Tool Works; CB-50.
    d. Marathon Industries, Inc.; 590.
    e. Mon-Eco Industries, Inc.; 55-40.
    f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: ASTM D1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-30.
   b. Foster Products Corporation, H. B. Fuller Company; 30-35.
   c. ITW TACC, Division of Illinois Tool Works; CB-25.
   d. Marathon Industries, Inc.; 501.
   e. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 degrees F.
4. Solids Content: ASTM D1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; Encacel.
   b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
   c. Marathon Industries, Inc.; 570.
   d. Mon-Eco Industries, Inc.; 55-70.

2. Water-Vapor Permeance: ASTM F1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 degrees F.
4. Solids Content: ASTM D1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Products, Division of ITW; CP-10.
   b. Foster Products Corporation, H. B. Fuller Company; 35-00.

c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
d. Marathon Industries, Inc.; 550.
e. Mon-Eco Industries, Inc.; 55-50.
f. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 degrees F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 100 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-52.
b. Foster Products Corporation, H. B. Fuller Company; 81-42.
c. Marathon Industries, Inc.; 130.
d. Mon-Eco Industries, Inc.; 11-30.
e. Vimasco Corporation; 136.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 degrees F.
5. Color: White.

2.7 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-76.
b. Foster Products Corporation, H. B. Fuller Company; 30-45.
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc.; 44-05.

e. Pittsburgh Corning Corporation; Pittseal 444.
f. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 degrees F.
5. Color: White or gray.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-76-8.
b. Foster Products Corporation, H. B. Fuller Company; 95-44.
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc.; 44-05.
e. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; CP-76.
b. Foster Products Corporation, H. B. Fuller Company.
c. Marathon Industries, Inc.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.8 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately two (2) oz/sq yd with a thread count of 10 strands by 10 strands/sq inch for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Vimasco Corporation; Elastafab 894.
b. Auburn Manufacturing, Inc.; AMI-TUF.
c. Mineral Seal Corporation; 3110G CeraTex Cloth.

B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately six (6) oz/sq yd with a thread count of 5 strands by 5 strands/sq inch for covering equipment.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; Chil-Glas No. 5.
b. Auburn Manufacturing, Inc.; AMI-TUF.
c. Mineral Seal Corporation; 3110G CeraTex Cloth.

C. Woven Polyester Fabric: Approximately one (1) oz/sq yd with a thread count of 10 strands by 10 strands/sq inch, in a Leno weave, for duct, equipment, and pipe.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
b. Childers Products, Division of ITW.

c. Vimasco Corporation; Elastafab 894.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of eight (8) oz/sq yd.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.
b. BHA Altair, LLC.

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; Metal Jacketing Systems.
    b. PABCO Metals Corporation; Surefit.
    c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A167 or ASTM A240.

    a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
    b. Material, finish, and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:

        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.

5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. H.B. Fuller Construction Products Inc.
b. Pittsburgh Corning Corporation; Pittwrap.
c. Polyguard; Insulrap No Torch 125.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: Three (3) inches.
3. Thickness: 11.5-mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two (2) percent.
6. Tensile Strength: 40-lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.

d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

2. Width: Three (3) inches.
3. Thickness: 6.5-mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: Two (2) percent.
6. Tensile Strength: 40-lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.
c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

2. Width: Two (2) inches.
3. Thickness: Six (6) mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18-lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
b. Compac Corp.; 120.
c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
d. Venture Tape; 3520 CW.

2. Width: Two (2) inches.
3. Thickness: 3.7-mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: Five (5) percent.
6. Tensile Strength: 34-lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products; Bands.
    b. PABCO Metals Corporation; Bands.
    c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A167 or ASTM A240, Type 304 or Type 316; 0.015 inch thick, 3/4-inch wide with wing or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4-inch wide with wing or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; Cupped Head Weld Pin.
        3) Midwest Fasteners, Inc.; Cupped Head.
        4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by two (2) inches square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
3) Production Fastening Systems, LLC; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030-inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.

2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030-inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, galvanized steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) GEMCO.
2) Midwest Fasteners, Inc.
3) Seastrom Manufacturing Co., Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. C & F Wire.

b. Childers Products.
c. PABCO Metals Corporation.
d. RPR Products, Inc.

2.14 CORNER ANGLES

A. PVC Corner Angles: 30-mils thick, minimum one (1) by one (1) inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040-inch thick, minimum one (1) by one (1) inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024-inch thick, minimum one (1) by one (1) inch, stainless steel according to ASTM A167 or ASTM A240, Type 304 or 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced four (4) inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at two (2) inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least four (4) inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least two (2) inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least two (2) inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least two (2) inches.

1. Comply with requirements in Section 07 84 13 for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least two (2) inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13.

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is three (3) inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately six (6) inches from each end. Install wire or cable between two (2) circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least three (3) inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum, at least 0.040-inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one (1) pipe diameter, whichever is thicker. Fill joints, seams, and

irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two (2) times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations required for servicing of equipment. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two (2) times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two (2) halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least two (2) inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two (2) coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Boiler Breechings and Ducts:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install 2-layer insulation with joints tightly butted and staggered at least three (3) inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least one (1) inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least three (3) inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one (1) layer of glass cloth or tape. Overlap edges at least one (1) inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at six (6) inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least one (1) inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.9 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at six (6) inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least one (1) inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space three (3) inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and three (3) inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing two (2) inches from one (1) edge and one (1) end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, one (1) inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two (2) times the insulation thickness but not less than three (3) inches.

5. Overlap unfaced blankets a minimum of two (2) inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced six (6) inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space three (3) inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and three (3) inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing two (2) inches from one (1) edge and one (1) end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, one (1) inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 degrees F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two (2) times the insulation thickness but not less than three (3) inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on

alternating sides of stiffener, hanger, and flange with pins spaced six (6) inches o.c.

3.11 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two (2) continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.12 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 84 13.

3.13 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting sections.

1. Flat Acrylic Finish: Two (2) finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one (1) location(s) for each duct system defined in the "Duct Insulation Schedule, General" article.
2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one (1) location(s) for each type of equipment defined in the "Equipment Insulation Schedule" article. For large equipment, remove only a portion adequate to determine compliance.
3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three (3) locations of straight pipe, three (3) locations of threaded fittings, three (3) locations of welded fittings, two (2) locations of threaded strainers, two (2) locations of welded strainers, three (3) locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.15 DUCT AND PLENUM INSULATION SCHEDULE, GENERAL

A. All items requiring insulation, factory or field-insulated, shall be in accordance with the requirement stated herein and with all local codes. The contractor shall coordinate the insulation requirements thereof and provide the appropriate insulation to satisfy the more stringent requirement(s).

B. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in non-conditioned space.
4. Indoor, exposed return located in non-conditioned space.
5. Type I, commercial, kitchen hood exhaust.
6. Indoor, concealed oven and warewash exhaust.
7. Indoor, exposed oven and warewash exhaust.
8. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
9. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
10. Outdoor, concealed supply and return.
11. Outdoor, exposed supply and return.

C. Items Not Insulated:

1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.
7. Direct buried ductwork encased in concrete trenches.

3.16 DUCT AND PLENUM INSULATION SCHEDULE

A. Cold Ductwork (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold ductwork:

a. Outdoor air intake ductwork between air entrance and coil or fan inlet or HVAC unit inlet.
b. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room air outlet.
c. Insulate neck and bells of supply diffusers.

d. HVAC return ductwork between room air inlet and return fan inlet, or HVAC unit inlet; except omit insulation on return ductwork located in return air-ceiling plenums.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:

a. Rigid mineral-fiber: 1-1/2" thick, increase thickness to 2" in exposed locations and machine, fan and equipment rooms.
b. Flexible mineral-fiber: 1-1/2" thick, application limited to concealed accessible locations.

B. Hot Ductwork (Above Ambient Temperature):

1. Application Requirements: Insulate the following hot ductwork:

a. Hot supply and return ductwork between fan discharge, or HVAC unit discharge, and room air outlet; except omit insulation on return ductwork located in return air ceiling plenums.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:

a. Rigid mineral-fiber: 2" thick in exposed locations and machine, fan and equipment rooms.
b. Flexible mineral-fiber: 2" thick, application limited to concealed accessible locations.

C. Dual Temperature Ductwork:

1. Application Requirements: Insulate the following dual temperature ductwork:

a. Hot/cold supply and return ductwork between fan discharge or HVAC unit discharge, and room terminal outlets; except omit insulation on return air ductwork located in return air ceiling plenums.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:

a. Rigid mineral-fiber: 2" thick in exposed locations and machine, fan and equipment rooms.
b. Flexible mineral-fiber: 2" thick, application limited to concealed accessible locations.

D. Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating, UL 1978 and ASTM E119.

3.17 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one (1) material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.

C. Cold Equipment (Below Ambient Temperature).

1. Application Requirements: Insulate the following cold equipment:

a. Refrigeration equipment, including chillers, tanks and pumps.
b. Drip pans under chilled equipment.
c. Chilled water pumps.
d. Expansion tanks.
e. Air-separators.
f. Pneumatic water tanks.
g. Heat exchangers.

2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 2" thick for cold surfaces above 35 degrees F (2 degrees C) and 3" thick for surfaces 35 degrees F (2 degrees C) and lower.
b. Cellular Glass: 3" thick for surfaces above 35 degrees F (2 degrees C) and 4-1/2" thick for surfaces 35 degrees F (2 degrees C) and lower.
c. Flexible Unicellular: 1" thick.

D. Hot Equipment (Above Ambient Temperature):

1. Application Requirements: Insulate the following hot equipment:

a. Boilers (not pre-insulated at factory).
b. Hot water storage tanks.
c. Water heaters.
d. Heat exchangers.
e. Condensate receivers.
f. Expansion tanks.
g. Air-separators.
h. Hot water pumps.
i. Condensate pumps.

2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 2" thick, except 3" thick for low-pressure boilers and steam-jacketed heat exchangers.
b. Calcium Silicate: 3" thick except 4-1/2" thick for low-pressure boilers and steam-jacketed heat exchangers.
c. Flexible Unicellular: 1" thick. Do not use for equipment operating above 180 degrees F.

3.18 PIPING INSULATION SCHEDULE, GENERAL

A. All items requiring insulation, factory or field-insulated, shall be in accordance with the requirement stated herein and with all local codes. The contractor shall coordinate the insulation requirements thereof and provide the appropriate insulation to satisfy the more stringent requirement(s).

B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Hot piping within radiation enclosures or unit cabinets.
2. Cold piping within unit cabinets provided piping is located over drain pan.
3. Drainage piping located in crawl spaces.
4. Underground piping, unless otherwise indicated.
5. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.19 PIPING INSULATION SCHEDULE

A. Sub-Zero Piping (Below 0 degrees F) (-18 degrees C)):

1. Application Requirements: Insulate the following sub-zero HVAC piping systems:

a. Low temperature refrigerant piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for all pipe sizes.
b. Cellular Glass: 2-1/2" thick for all pipe sizes.

B. Sub-Freezing Piping (0 to 39 degrees F (-18 to 4 degrees C)):

1. Application Requirements: Insulate the following sub-freezing HVAC piping systems:

a. Refrigerant suction lines between evaporators and compressors. Brine refrigerant piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for all pipe sizes.
b. Cellular Glass: 1-1/2" thick for all pipe sizes.

C. Cold Piping (40 degrees F (4.4 degrees C) to ambient):

1. Application Requirements: Insulate the following cold HVAC piping systems:

a. HVAC glycol piping.
b. HVAC chilled water supply and return piping.
c. HVAC make-up water piping.
d. Air conditioner condensate drain piping.
e. Free cooling condenser water piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for all pipe sizes.
b. Cellular Glass: 1-1/2" thick for all pipe sizes.
c. Flexible Unicellular: 1-1/2" thick for all pipe sizes (up to largest size permitted).

D. Dual Temperature Piping (40 degrees to 250 degrees F (4.4 to 121 degrees C)).

1. Application Requirements: Insulate the following dual temperature HVAC piping systems:

a. HVAC hot/chilled water supply and return piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation.

a. Fiberglass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".
b. Cellular Glass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".

E. Hot Low Pressure Piping (to 250 degrees F (121 degrees C)):

1. Application Requirements: Insulate the following hot low pressure HVAC piping systems.

a. HVAC hot water supply and return piping.
b. Hot service drains and vents.
c. Condenser water supply and return piping.
d. Heated fuel piping.
e. Hot gas refrigerant piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".
b. Calcium Silicate or Cellular Glass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2-1/2" thick for pipe sizes over 1-1/2".

F. Hot Medium Pressure Piping (to 305 degrees F (152 degrees C).

1. Application Requirements: Insulate the following hot medium pressure HVAC piping:

a. HVAC hot water supply and return piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".
b. Calcium Silicate or Cellular Glass: 2" thick for pipe sizes up to and including 1-1/2", 3" thick for pipe sizes over 1-1/2".

G. Hot Low Pressure Piping (to 250 degrees F (121 degrees C)):

1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi).

a. Low pressure steam and condensate piping

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".
b. Calcium Silicate or Cellular Glass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2-1/2" thick for pipe sizes over 1-1/2".

H. Hot Medium Pressure Piping (to 305 degrees F (152 degrees C).

1. Application Requirements: Insulate the following hot medium pressure HVAC piping (steam piping from 16 to 75 psi):

   a. Medium pressure steam and condensate piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

   a. Fiberglass: 1-1/2" thick for pipe sizes up to and including 1-1/2", 2" thick for pipe sizes over 1-1/2".
   b. Calcium Silicate or Cellular Glass: 2" thick for pipe sizes up to and including 1-1/2", 3" thick for pipe sizes over 1-1/2".

3.20 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one (1) material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums:

1. Stainless Steel, Type 304 or 316, Smooth 2B Finish: 0.020-inch thick.

D. Piping:

1. Stainless Steel, Type 304 or 316, Smooth 2B Finish: 0.020-inch thick.

3.21 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material. Refer to Section 23 21 13.13 for additional information.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 RELATED SECTIONS

A. Section 01 91 00 - Building Commissioning Requirements

B. Division 23 – HVAC

C. Division 26 - Electrical

D. Division 27 - Communications

E. Division 28 - Electronic Safety and Security Systems

1.3 REQUIREMENTS

A. The commissioning process requires the participation of Division 23 "HVAC" to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 23 "HVAC" shall fulfill commissioning responsibilities assigned to Division 23 in accordance with Section 01 91 00.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.

B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with Section 01 91 00.

C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. The intent of functional testing is to verify system operation is in accordance with design intent. Thorough test procedures will be utilized to verify systems and equipment through their full sequence of operations.

B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with Section 01 91 00.

C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

A. Pre-Functional Checklists and Functional performance testing procedures will be performed on, but not limited to, the following system types (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 23 or by applicable codes.):

1. Hot Water System including boiler(s), combustion air fan, pumps, auto. chemical feed system, and other related ancillary equipment.
2. Chilled Water System including chiller(s), pumps, auto. chemical feed system, and other related ancillary equipment.
3. All Air Handling Units.
4. Split System Air Conditioning units and associated air-cooled condensers.
5. Computer Room Air Conditioning units and associated Drycooler(s).
6. All Unit Heaters and Cabinet Unit Heaters
7. All Exhaust Fans including kitchen and fume hood systems
8. All Variable Air Volume Boxes and associated reheat coils
9. All Fin Tube Radiation
10. All Radiant Panels
11. Spot check of testing adjusting and balancing
12. Building Management Control System
13. Direct Digital Controls and system interlocks

3.4 SAMPLE CHECKLISTS

A. See Attached.

Functional Test
HOT WATER SYSTEM including Boilers, Pumps and all related ancillary equipment

IMPORTANT:

Please refer to the Master Deficiency and Resolution Log for numbers referenced in parentheses, which will indicate deficiencies discovered and resolved. For quick reference you will find, in the front of this section a list of Master Deficiency and Resolution Log items pertaining only to this section.

1. Submittal / Approvals

Submittal: The above equipment and systems integral to them are complete and ready for functional testing. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed.

2. Prerequisite Checklist

a. All associated equipment has been started up and is ready for functional testing.
b. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including balancing valves and sensor calibrations completed.
b. All A/E punchlist items for this equipment corrected.
c. Safeties and operating ranges reviewed.
d. This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
e. Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
f. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

	Boilers and System		
Check Equip Tag➔	**B-#**	**B-#**	**COMMENTS**
General Installation			
Permanent labels affixed			
Casing condition good: no evidence of damage			
Concrete pad provided (4-6") to ensure proper condensate drainage			
Thermal insulation properly installed			

	Boilers and System		
Check Equip Tag➔	**B-#**	**B-#**	**COMMENTS**
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)			
Clean up of equipment completed per contract documents			
Installation of combustion air fan and associated motorized damper			
Relief valve on boiler properly piped			
Boiler drain valves			
ASME Pressure relief valve			
Sensors calibrated			
HWR Manual Isolation Valve			
HWR Main Temperature Sensor-ATC			
HWS Main Temperature Sensor-ATC			
HWS Main isolation valve upstream of Air Separator			
HWR Isolation Valves to Boilers			
Emergency Boiler Switch at Door(s)			
Exhaust vent pipe completely sealed to prevent leakage of combustion products			
Manual Gas shutoff valve in place in case of overheating or gas supply failure. Location apparent			
Minimum clearance has been met as indicated, or as otherwise required by the unit manufacturer. Sides: 24 Inches Front: 24 Inches Rear: 30 Inches Top: 18 Inches			
Floor drain in place or condensate pump used to remove condensate			
Condensate drain trap associated fitting and drain line are removable for maintenance			
If using a sealed combustion air configuration, each unit must have a min of 8 inch diameter connection at unit.			
Valves and Piping and associated equipment			
Expansion tank installed			

	Boilers and System		
Check Equip Tag➔	**B-#**	**B-#**	**COMMENTS**
Expansion Tank Auto Air vent			
Expansion Tank drain valve installed			
Expansion Tank Isolation Valve			
Air Separator in place between boilers and pumps			
Air Separator high capacity air vent installed			
Air Separator Drain in place			
Air Separator between boiler hot water supply and pump suction			
Piping arrangement installed per the contract documents			
Installation of chemical pot feeder and support devices			
Pipe fittings complete and pipes properly supported by floor, ceiling or walls and NOT by unit			
Pipes properly labeled			
Pipes properly insulated			
Valves properly labeled			
Valves installed in proper direction			
Piping system properly flushed			
No leaking apparent around fittings			
PRV - Automatic Fill and Check Valve installed on Makeup Water			
Pressure gauge installed after PRV on Cold Water Fill			
Glycol makeup Units fill valve in place			
Glycol makeup manually adjustable pressure switch			
Glycol makeup Control Panel in place			
Glycol makeup low water pilot light in place			
Glycol makeup manual shutoff on CW makeup			
Glycol makeup High level switch dry contacts in place to alarm at BMS			
Glycol makeup Low level switch dry contacts in place to alarm at BMS			
Glycol Makeup pump and piping (w/ instrumentation) according to detail.			
Chemical pot feeder installed as per detail			

	Boilers and System		
Check Equip Tag➔	**B-#**	**B-#**	**COMMENTS**
Electrical and Controls			
Power disconnects in place and labeled			
Electrical conduit and hardware does not interfere with removal of any unit covers or inhibit maintenance/service			
No other devices share the same electrical circuit as the boilers			
All electric connections tight			
Safeties in place and operable			
Low water cut-off switch			

	Pumps		
Check Equip Tag➔	**P-#**	**P-#**	**COMMENTS**
General Installation			
Permanent labels affixed			
Casing condition good: No Damage			
Vibration Isolation in place			
Piping and Valves			
Common pressure gauge installed			
Piping insulated			
Piping labeled			
Associated valve appropriately labeled with valve tags			
Triple Duty Valve installed			
Isolation Valves installed as per documents			
Drain installed with			
Manual air vent installed			
Electrical and Controls			
VFD installed as per contract documents			
Disconnect in place and labeled			
All control devices installed properly			

The checklist items of Part 3 are all successfully completed for given trade ☐ YES ☐ NO

4. Performance Tests

Test	Compli-ance/Non-Compliance	Compli-ance/Non-Compliance	Comments
Equip Tag➔	**B-#**	**B-#**	
Performance Tests			
Calibration of BMCS HWS and HWR			
Calibration of outdoor air sensor			
Capability of the temperature control system to stop/start boiler. Verify the motorized damper on combustion air fans opens prior to the start of the boiler.			
Hot water reset schedule capability at BMCS OA 20ºF = 140ºF HWS OA ≥60ºF = 120ºF HWS			
Record sequencing and/or operation of boilers when system is activated such that both boilers operate to maintain setpoint.			
Boiler safeties, staging and modulation shall be controlled thru the boiler control panel provided by the MFG			
Boilers operate in parallel			
Boilers are off when outdoor air is above 65 deg. F. adj.			
Boiler start time delay to prevent short cycling.			
Operation of hi water temp safeties for boilers.			
Operation of low water cut off boiler Safeties for both boilers			
Boiler alarm bells in place and functional??			
Installation of a low temperature water alarm signal at the BMCS. Record setpoint.			
Boiler/Burner Emergency Shutdown Switches at each entry door hardwired to boiler and burner controls			
Burner status in place			
Operating status of pumps			
Startup report performed only by manufacturer trained startup and service personnel has been provided and includes the performance of the combustion air calibration, proper set up of controls and limits, proper setup of modes of operation, and testing of all safety devices			

Graphic (Operator Station) Display	Compliance or Non Compliance
Equipment identification	
Boiler Enable/Disable	
Boiler(s) alarm status	
Supply water temperature sensor	
Supply water temperature setpoint	
Return water temperature sensor	
Pump Start/Stop	
Pump(s) Status	
Pump(s) VFD status	
Pump(s) VFD speed	
Pump(s) VFD alarm	
Differential pressure setpoint	
Differential pressure status	
Bypass valve command	
Outside air temperature indication	
Glycol Unit Identification	
Glycol Pump Status	
Glycol high level alarm (thru dry contacts)	
Glycol low level alarm (thru dry contacts)	
Glycol percentage alarm	

The checklist items of Part 4 are all successfully completed for given trade ☐ ***YES*** ☐ ***NO***

5. Functional Testing Record

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				Heating System	
				B-#	B-#
1	Heating System Enable	Override OA sensor and set below 60 deg F	Lead Boiler, associated Lead Primary Pump and Lead Secondary Hot Water Pump shall be energized on along with the oil transfer pumps		

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				Heating System	
				B-#	B-#
2	Heating System Disable	Override OA sensor and set above 60 deg F	All boilers shall be disabled along with their associated primary pumps and the lead secondary pump.		
3	Operating control	Change parameters of the reset schedule to simulate a change in need for hot water supply temperature to the loop. Parameter setting shall be as follows but fully adjustable. **OA** **Supply Temp** 20ºF 140ºF ≥60ºF 120ºF	Ensure the BMS recalculates the system hot water setpoint. Boiler shall operate and burner shall control via internal controls until building hot water supply temperature in the common header reaches the setpoint (based on a reset schedule inversely proportional to outside air temperature		
4	Low Water Level Fault	Simulate a low water condition by tripping the low water cutout switch	Burner shuts down and alarm sent to BMS		
5	High Water Temperature Fault	Adjust the automatic over-temperature switch on front of unit. Lower the temp limit switch setting to match the displayed outlet temp	The unit should shut down. The fault indicator should start flashing and a high water temp switch open fault message should be displayed. Be sure to return the switch to its original setting to reset.		
6	Flame Fault	Set the On/Off switch to OFF. Place the unit in the Manual Mode and set the firing rate between 14% and 30%. Close the manual gas shutoff valve	The unit shall shut down		

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				Heating System	
				B-#	B-#
7	Boiler and Burner Emergency Shutdown Control	Interrupt each burner safety circuit to turn off the boiler/burner by manually operated remote shutdown switch located at each boiler room door	Burner/boiler shall shutdown as it the switch is hardwired to the boiler/burner controls		
8	Autofill Make-up Unit	NOTE: Unit is controlled through factory supplied controls. Ensure that the following is happening	When the system pressure drops below setpoint of the pressure switch, the pump shall start and add fluid from the tank into the system. When the pressure setpoint is satisfied, the pump shall stop. A low condition (low level switch) will stop or not allow the pump to start.		

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				P-#	P-#
1	Secondary Pumps Enable	Enable the heating system	Lead secondary pump shall operate continuously when activated.		
2	Secondary Pump Disable	Disable the heating system	The secondary pumps shall not run when the heating system is not energized.		
3	Secondary Pump Failure	Manually fail the lead secondary pump at VFD	An alarm shall be sent to the BMS and the lag pump shall be enabled and shall run continuously		
4	Secondary Pump Lead/Lag Swap	Set up trends on Secondary Pump Status.	Pumps shall alternate to equalize runtime. Selection of the lead and lag pump shall be evaluated on a weekly basis. The pump with the last amount of run time is lead. The remaining is the lag.		
		Manually swap the pumps via BMS controls	Ensure that the lead secondary pump swaps		
5	Secondary Pump Speed	Change the differential pressure (dp) setpoint	The pumps are controlled by (2) system dp sensors thru the associated VFD's. The controller will monitor both sensors and will control to maintain the setpoint using the sensor which is farthest from setpoint. The VFD shall ramp up and down to maintain the differential pressure setpoint per sensor(s).		
	Bypass Valve Operation	Simulate a situation where the frequency of the operating pump VFD drops to 15 HZ.	Should the frequency of the operating pump drop to 15 HZ, the bypass valve shall open to maintain system pressure		

The functional tests of Part 5 have all passed for given trade ☐ ***YES*** ☐ ***NO***

END OF SECTION

PART 1 - GENERAL

1.1 OVERVIEW

A. This specification defines the minimum equipment and performance requirements for a Direct Digital Control (DDC) Building Management Control System (BMCS).

B. It shall be understood that the drawings and specifications describe the approximate locations of the work. Do not scale the drawings to determine exact positions and clearances. Obtain from Architect, Engineer or the Owner any dimensions not shown.

C. Details of construction and of workmanship where not specifically described herein or indicated on the drawings shall be subject to the Engineer's or Owner's approval. It is the intent of these specifications to provide complete systems, left in good working order, ready for operation, including necessary labor and materials, whether or not specifically shown on the drawings or mentioned herein.

D. Before submitting proposals, examine the specifications and all drawings relating to the work and become fully informed as to the extent and character of the work and the relation of the work to that of other Sections. Examine the drawings of other Sections to become familiar with all the problems and details of the building construction and to note conditions which affect the work.

E. The intent of this specification is to utilize the Owner’s existing Web-Based server. All new data, databases and graphics will be accessible through the existing server software. The system will also utilize the identical programming and graphics software. No other software shall be installed on the existing server.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.3 SECTION INCLUDES

A. Control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.4 RELATED SECTIONS

A. Section 01 23 00 - Alternates: Procedures for alternates that relate to this section.

B. Section 01 26 16 - Contractor's Request for Information: Procedure for submitting a "Request For Information" (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 25 00 - Substitution Procedures.

D. Section 01 91 03 - Building Commissioning Requirements.

E. Section 23 05 19 - Meters and Gages for HVAC Piping: Measuring equipment that relates to this section.

F. Section 23 08 00 - Commissioning of HVAC.

G. Section 23 09 93 - Sequence of Operations for HVAC Controls: Requirements that relate to this section.

H. Applicable sections of Division 26 specifications.

1.5 DEFINITIONS

A. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

B. BACnet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to the latest version of ASHRAE standard 135.

C. Binary: A two-state system where an "ON" condition is represented by one discrete signal level and an "OFF" condition is represented by a second discrete signal level.

D. Building Management Control System (BMCS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMCS Contractor and to be interfaced to the associated work of other related trades.

E. BMCS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMCS work.

F. Control Sequence: A BMCS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.

G. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMCS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control

algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

H. BMCS Network: The total digital on-line real-time interconnected configuration of BMCS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.

I. Node: A digitally programmable entity existing on the BMCS network.

J. BMCS Integration: The complete functional and operational interconnection and interfacing of all BMCS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMCS as required by this Division.

K. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

L. PC: IBM-compatible Personal Computer from a recognized major manufacturer

M. Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMCS Contractor’s cost to the designated third party trade contractor for installation. BMCS Contractor shall connect furnished items to the BMCS, calibrate, test, commission, warrant and document.

N. Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BMCS wiring and terminations. All wiring shall be plenum rated, where applicable, when installed in ceilings used as plenums for the movement of air (i.e. return, transfer, etc…). Coordinate with the floor plans to confirm where applicable.

O. Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

P. Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMCS network nodes.

Q. Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMCS industry for real-time, on-line, integrated BMCS configurations.

R. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.

S. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.

T. The following abbreviations and acronyms may be used in describing the work of this Division:

ADC - Analog to Digital Converter
AI - Analog Input
AN - Application Node
ANSI - American National Standards Institute
AO - Analog Output
ASCII - American Standard Code for Information Interchange
ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG - American Wire Gauge
CPU - Central Processing Unit
CRT - Cathode Ray Tube
DAC - Digital to Analog Converter
DDC - Direct Digital Control
DDCP - Direct Digital Control Panel
DI - Digital Input
DO - Digital Output
EEPROM - Electronically Erasable Programmable Read Only Memory
EMI - Electromagnetic Interference
FAS - Fire Alarm Detection and Annunciation System
GUI - Graphical User Interface
HOA - Hand-Off-Auto
ID - Identification
IEEE - Institute of Electrical and Electronics Engineers
I/O - Input/Output
LAN - Local Area Network
LCD - Liquid Crystal Display
LED - Light Emitting Diode
MCC - Motor Control Center
NC - Normally Closed
NIC - Not In Contract
NO - Normally Open
OWS - Operator Workstation
OAT - Outdoor Air Temperature
PC - Personal Computer
RAM - Random Access Memory
RF - Radio Frequency
RFI - Radio Frequency Interference
RH - Relative Humidity
ROM - Read Only Memory

RTD - Resistance Temperature Device
SPDT - Single Pole Double Throw
SPST - Single Pole Single Throw
XVGA - Extended Video Graphics Adapter
TBA - To Be Advised
TCP/IP - Transmission Control Protocol/Internet Protocol
TEC - Terminal Equipment Controller
TTD - Thermistor Temperature Device
UPS - Uninterruptible Power Supply
VAC - Volts, Alternating Current
VAV - Variable Air Volume
VDC - Volts, Direct Current
WAN - Wide Area Network

1.6 DESCRIPTION OF WORK

A. System Description

1. All control programs including “field level” programming, will be accessible, including uploading and downloading, through the existing server software. No proprietary (manufacturer specific) software shall be required to configure or program the field level controllers.
2. The BMCS Contractor shall furnish and install a fully integrated building automation system, incorporating DDC for energy management, equipment monitoring and control as herein specified. The system shall include all required computer software and hardware, controllers, sensors, transmission equipment, system workstations, local panels, conduit, wire, installation, engineering, database and setup, supervision, commissioning, acceptance test, training, warranty service and, at the owner's option, extended warranty service.
3. The BMCS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. Systems requiring additional software (to enable a standard Web browser) to be resident on a client machine, or manufacture-specific browsers shall not be acceptable.
4. The BMCS shall communicate to third party systems such as chillers, boilers, air handling systems, energy metering systems, other energy management systems, access control systems, fire-life safety systems, and other building management related devices with open, interoperable communication capabilities. Coordinate with the work by Division 26, 27 & 28 to provide necessary BMCS components to satisfy the integration of all other systems.
5. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project.
6. All control panel locations must be pre-approved by the Owner.
7. Control output must be; dc 2-10, 0-10, 4-20, no floating control inputs allowed.

B. Furnish a Siemens BACnet DDC control system, including a Microsoft Windows operator's workstation, based on a distributed control system in accordance with this specification for all mechanical systems, including but not limited to; chillers (CH), boilers (B), cooling towers (CT), air handling units (AHU), rooftop air handling units (RTU), heat exchangers (HX), convertors (c), computer room air conditioning (CRAC) units, split air conditioning systems (AC and ACCU's), VAV terminals, pumps (P), cabinet unit heaters (CUH), unit heaters (UH), fans (EF & KHE), etc… The BMCS shall be complete in all respects, including all labor, control accessories, hardware, software, and peripheral devices necessary to execute the sequence of operations.

C. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2001, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.

D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.
2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
8. Manage Control System Hardware. Authorized operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. Software:

1. Operating System: Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows.
2. System Graphics: Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
3. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
4. Animation: Graphics shall be able to animate by displaying different image files for changed object status.
5. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.
6. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

F. System Tools:

1. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from site server or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.
2. Automatic System Database Configuration: The web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
3. Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
4. System Configuration: Authorize operators shall be able to configure the system.

5. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
6. Security: System shall require a user name and password to view, edit, add, or delete data.
7. Operator Access: Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator's accessible functions based on equipment or geographic location.
8. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
9. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
10. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
11. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 23 09 93 "Sequence of Operations for HVAC Controls." Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
12. Alarm Messages: Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
13. Alarm Reactions: Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
14. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
15. Trend Configuration: Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Section 23 09 93 "Sequence of Operations for HVAC Controls." Trends shall be BACnet trend objects.
16. Object and Property Status and Control: Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
17. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

18. Standard Reports: Furnish the following standard system reports:
19. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
20. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
21. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:
22. Alarm History.
23. Trend Data: Operator shall be able to select trends to be logged.
24. Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

G. Energy Reports. System shall include an easily configured energy reporting tool that provides the capabilities described in this section.

1. The energy reporting tool shall be accessible through the same user interface (Web browser or operator workstation software) as is used to manage the BMCS.
2. The energy reporting tool shall be preconfigured by the Contractor to gather and store energy demand and consumption data from each energy source that provides metered data to the BMCS. Meter data shall be stored at 5 minute intervals unless otherwise specified in the Sequence of Operation provided in Section 23 09 93. This data shall be maintained in an industry standard SQL database for a period of not less than five years.
3. The energy reporting tool shall allow the operator to select an energy source and a time period of interest (day, week, month, year, or date range) and shall provide options to view the data in a table, line graph, bar graph, or pie chart. The tool shall also allow the operator to select two or more data sources and display a comparison of the energy used over this period in any of the listed graph formats, or to total the energy used by the selected sources and display that data in the supported formats.
4. The energy reporting tool shall allow the operator to select an energy source and two time periods of interest (day, week, month, year, or date range) and display a graph that compares the energy use over the two time periods in any of the graph formats listed in the previous paragraph. The tool shall also allow the operator to select multiple energy sources and display a graph that compares the total energy used by these sources over the two time periods.
5. The energy reporting tool shall allow the operator to easily generate the previously described graphs "on the fly," and shall provide an option to store the report format so the operator can select that format to regenerate the graph at a future date. The tool shall also allow the user to schedule these reports to run on a recurring basis using relative time periods, such as automatically generating a consumption report on the first Monday of each month showing consumption over the previous month. Automatically generated reports shall be archived on

the server in a common industry format such as Adobe PDF or Microsoft Excel with copies e-mailed to a user editable list of recipients.

6. The energy reporting tool shall be capable of collecting and displaying data from the following types of meters: (Refer to the contract documents for the applicable utilities to meter.)

    a. Electricity
    b. Gas
    c. Chilled Water
    d. Condenser Water
    e. Heating Hot Water
    f. Potable Water

7. Heating and cooling degree days. (May be calculated from sensor data rather than metered.)
8. The user shall have the option of using Kw (Kwh) or Btu/hr (Btu) as the units for demand and consumption reports. Multiples of these units (MWH, kBtu, etc.) shall be used as appropriate. All selected sources shall be automatically converted to the selected units. The user shall similarly have the option of entering facility area and occupancy hours and creating reports that are normalized on an area basis, an annual use basis, or an occupied hour basis.
9. The user shall have the option of entering benchmark data for an individual facility or a group of facilities.
10. The user shall have the option of displaying any or all of the following data on any chart, line, or bar graph generated by the energy reporting tool:
11. Low/High/Average value of the metered value being displayed.
12. Heating and/or Cooling Degree Days for the time period(s) being displayed.

H. The BMCS shall possess a modular architecture, permitting expansion through the addition of more Direct Digital Control Panels (DDCP's), Terminal Equipment Controllers (TEC’s), sensors, actuators, and/or operator terminals.

I. The Controls System shall be designed and implemented entirely for use and operation on the Internet and the Owner’s Intranet. All aspects of the Controls Systems Operator Interface shall be provided to operate through an IT industry standard Web Browsers such as Internet Explorer or Netscape or approved equivalent. The Web Browser based Operator Interface provided shall not require the procurement or licensing of any special or proprietary software from the Controls Contractor or its suppliers for the Controls Systems OWS.

J. Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft Data Engine (MSDE) or Microsoft SQL Server as dictated elsewhere in this specification.

K. The work of the single BMCS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.

L. The BMCS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMCS.

M. Provide a complete, neat and workmanlike installation. Use only employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

N. Manage and coordinate the BMCS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

O. The BMCS as provided shall incorporate, at minimum, the following integrated features, functions and services:

1. Operator information, alarm management and control functions.
2. Enterprise-level information and control access.
3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
4. Diagnostic monitoring and reporting of BMCS functions.
5. Offsite monitoring and management access.
6. Energy management
7. Standard applications for terminal HVAC systems.
8. Indoor Air Quality monitoring and control

1.7 WORK BY OTHERS

A. The Division 26 electrical contractor shall:

1. Supply, mount, and provide power wiring to all fire alarm devices, including but not limited to: combination fire/smoke dampers, smoke dampers and smoke detectors.
2. Install and provide all power wiring to the motor controllers and Variable Frequency Drives provided by the mechanical contractor.

B. The BMCS Contractor shall:

1. Provide 120 volts to each Distributed Digital Control Panel (DDCP), Application Specific Controller (ASC), and for Terminal Equipment Controller (TEC), except for the TEC's that serve the variable air volume (VAV) terminal boxes. Refer to VAV terminal box flow and control diagram for additional information.

C. The Variable Air Volume (VAV) Terminal Unit Manufacturer shall:

1. Mount the TEC, damper actuator and air velocity sensor on each terminal unit.
2. Provide and mount an averaging air velocity sensor suitable for interfacing with the TEC flow transducer.

D. The HVAC contractor shall:

1. Install control valves and separable wells furnished by the BMCS contractor.
2. Install all necessary piping connections required for flow devices.

E. The sheet metal contractor shall:

1. Provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
2. Assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
3. Provide sheet metal baffle plates for air handling unit mixing boxes when required by BMCS contractor to eliminate stratification and provide air volumes specified. Locate baffles by experimentation and affix and seal permanently in place only after stratification problem has been eliminated.
4. Provide access doors or other means of access through ducts for servicing control equipment.
5. Install all automatic dampers provided by the BMCS contractor.
6. Provide a minimum of three (3) duct diameters (minimum 36") of straight duct upstream from every air terminal unit inlet.
7. Provide for dry storage of terminal units and mounted TEC's upon receipt at job site.
8. Notify the BMCS contractor that the terminal units are ready for inspection. Every terminal unit shall be installed after the BMCS contractor has approved the TEC installation.
9. Insure all TEC's are located a minimum of three (3) feet from all obstructions (walls, pipes, ducts, etc.) so as to remain accessible.
10. Install all air flow measuring devices in equipment and ductwork provided by the BMCS contractor.

1.8 WIRING

A. Installation of the entire building management system shall be by skilled electricians and mechanics, all of whom are properly licensed, trained and qualified for this work. All wiring shall be installed in accordance with Division 26 electrical specifications.

B. Supervision and checkout of the system shall be by local branch engineers and technicians directly employed by the Control contractor.

C. Power wiring for the DDCP's and TEC's shall be provided by the BMCS contractor from the nearest power panel for this purpose.

D. Electrical wiring for the BMCS shall be performed by qualified electricians directly subcontracted by the Control contractor.

1.9 SYSTEM TURNOVER AND SERVICE

A. Upon completion of the installation, the BMCS contractor shall start up the system and perform all necessary testing and run diagnostics to ensure proper operation. An acceptance test in the presence of the owner representative shall be performed. The acceptance test shall consist of a point-to-point checkout within each DDCP to insure proper operation of all system components.

B. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

C. Problems which occur within approved hardware or software shall be corrected in an appropriate fashion under warranty. Any such occurrence shall not void previous approval; however, the BMCS contractor shall be responsible to attend to, and remedy, such items within the warranty period. Appropriate logs, schedules, and reports shall be maintained to reflect these items and their redress.

1.10 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

    a. Water Temperature: Plus or minus one (1) degree F.
    b. Water Flow: Plus or minus five (5) percent of full scale.
    c. Water Pressure: Plus or minus two (2) percent of full scale.
    d. Space Temperature: Plus or minus one (1) degree F.
    e. Ducted Air Temperature: Plus or minus one (1) degree F.
    f. Outside Air Temperature: Plus or minus two (2) degrees F.
    g. Dew Point Temperature: Plus or minus three (3) degrees F.
    h. Temperature Differential: Plus or minus 0.25 degrees F.
    i. Relative Humidity: Plus or minus five (5) percent.
    j. Airflow (Pressurized Spaces): Plus or minus three (3) percent of full scale.
    k. Airflow (Measuring Stations): Plus or minus five (5) percent of full scale.
    l. Airflow (Terminal): Plus or minus 10 percent of full scale.
    m. Air Pressure (Space): Plus or minus 0.01-inch wg.
    n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
    o. Carbon Monoxide: Plus or minus five (5) percent of reading.
    p. Carbon Dioxide: Plus or minus 50 ppm.
    q. Electrical: Plus or minus five (5) percent of reading.

1.11 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

E. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.

F. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

G. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

H. Qualification Data: For installer and manufacturer.

I. Field quality-control test reports.

J. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

1.12 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this project.

1. Manufacturer must prove that he has been engaged in the production, installation and service of this type of equipment for at least ten (10) years and has a fully equipped; factory trained and authorized service organization.
2. The BMCS Contractor shall be a recognized, installer and service provider of BMCS
3. The BMCS Contractor shall have been an authorized installing contractor for the manufacturer of the BACnet components for a minimum of five (5) years.
4. The BMCS Contractor shall have a branch facility within a 50-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

B. Final determination of compliance with these specifications shall rest solely with the Owner and Engineer who will require proof of prior satisfactory performance.

C. For any equipment submitted for approval, the BMCS contractor shall state what, if any, specific points of system operation differ from these specifications.

D. The BMCS contractor shall continue to bear the liability for replacement of substituted equipment in the event that the equipment fails to perform as specified, or to meet approval of all authorities having jurisdiction, within twelve (12) months after beneficial use by the owner.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASHRAE 135 for DDC system components.

G. Workplace Safety and Hazardous Materials:

1. Provide a safety program in compliance with the Contract Documents.
2. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
3. The Contractor and its employees and subtrades comply with federal, state and local safety regulations.
4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.
5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.
9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

H. Quality Management Program:

1. Designate a competent and experienced employee to provide BMCS Project Management. The designated Project Manger shall be empowered to make technical, scheduling and related decisions on behalf of the BMCS Contractor. At minimum, the Project Manager shall:

    a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.

b. Manage the financial aspects of the BMCS Contract.
c. Coordinate as necessary with other trades.
d. Be responsible for the work and actions of the BMCS workforce on site.

1.13 DELIVERY, STORAGE AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at project completion.

1.14 COORDINATION (Where Sections are applicable)

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Section 26 09 43 to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Section 26 24 16 to achieve compatibility with starter coils and annunciation devices.

D. Coordinate equipment with Section 27 53 13 to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Section 28 13 00 to achieve compatibility with equipment that interfaces with that system.

F. Coordinate equipment with Section 28 16 00 to achieve compatibility with equipment that interfaces with that system and with building master clock.

G. Coordinate equipment with Section 28 31 00 to achieve compatibility with equipment that interfaces with that system.

H. Coordinate equipment with Section 28 31 12 to achieve compatibility with equipment that interfaces with that system.

I. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

J. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00.

1.15 WARRANTY

A. Warrant all work as follows:

1. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.
2. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. If the work specified is split into multiple contracts or a multiphase contract, then each contract or phase shall have a separate warranty start date and period.
3. At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Engineer, the Engineer shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this Specification. The date of acceptance shall be the start of warranty.
4. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the contractor shall be provided at no charge during the warranty period. All corrective software modifications made during the warranty period shall be updated on all user documentation and on user and manufacturer archived software disks. Any upgrades or functional enhancements associated with the above-mentioned items can also be provided during the warranty period for an additional charge to the Owner by purchasing an in-warranty service agreement from the contractor. Written authorization by the Owner shall, however, be granted prior to the installation of any of the above-mentioned items.
5. Exception: Contractor shall not be required to warrant reused devices, except for those that have been rebuilt or repaired. Contractor shall warrant all installation labor and materials, however, and shall demonstrate that all reused devices are in operable condition at the time of the Engineer's acceptance.

B. Service all work as follows: Provide warranty service in accordance with the warranty section of this Specification. In addition, provide scheduled maintenance on all control system apparatus, including valves, dampers, linkages, control panels, interfaces, direct digital control systems, OWS's, PCs, software, and application programs. Maintenance shall consist of:

1. Scheduled preventive maintenance (p.m.) visit twice a year to audit system performance. Each p.m. visit shall include exercising each control loop and control sequence for performance. A log of each loop tested and each control sequence verified shall be reviewed with the Owner.

2. Provide emergency service for parts and labor on an as-needed basis. Response to an emergency call shall be four hours maximum on Monday-Friday and eight hours maximum on holidays and weekends.
3. Provide remote-service diagnostic monitoring from the nearest service location. At the request of the Owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints. The Owner will provide a dedicated telephone line or Internet connection to the system.
4. Contractor shall have the ability to provide verification of completed work order or preventive maintenance within one hour of the completion of that service or maintenance action. A paperless version is preferred and may be required.
5. Contractor shall have the ability to receive service requests via an Internet web site or a centralized call center. E-mail requests are not acceptable.
6. Provide a separate written quotation with the submittal for extension of the maintenance for Years 2, 3, 4, and 5.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 CONTROL SYSTEM

A. Manufacturers:

1. “Basis of Design”

a. Siemens, no substitutions permitted.

B. Controls shall be microprocessor based Interoperable controllers in accordance with the JSR-60 Baja Specification. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

C. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line. The use of field level controllers from multiple manufacturers is acceptable provided no proprietary configuration or programming

software is needed. All field level controllers must be fully configurable through the automation level controller and/or software.

D. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

E. The intent of this specification is to utilize the Owner's existing Web-Based System. All new data, databases and graphics will be accessible through the existing server software. The system will also utilize the identical programming and graphics software.

F. Access to the control system will remain constant to the existing access to other buildings utilizing the same server with unlimited simultaneous users. No other programs will be required or installed on the existing server.

G. All control programs including "field level" programming, will be accessible, including uploading and downloading, through the existing server software.

H. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, thermal graphics and control device depicted by point-and-click graphics.

I. Control system shall include the following: (Where applicable, coordinate with work by other sections.)

1. Interior Lighting specified in Section 26 51 00.
2. Exterior Lighting specified in Section 26 56 00.
3. Fire alarm system specified in Section 28 31 11.

2.3 DDC EQUIPMENT

A. Equipment:Existing Campus head-end shall be updated as required to monitor and control all new DDC control functions.

B. Software:

1. Application Software:

a. I/O capability from operator station.
b. System security for each operator via software password and access levels.
c. Automatic system diagnostics; monitor system and report failures.
d. Database creation and support.

e. Automatic and manual database save and restore.
f. Dynamic color graphic displays with up to 10 screen displays at once.
g. Custom graphics generation and graphics library of HVAC equipment and symbols.
h. Alarm processing, messages, and reactions.
i. Trend logs retrievable in spreadsheets and database programs.
j. Alarm and event processing.
k. Object and property status and control.
l. Automatic restart of field equipment on restoration of power.
m. Data collection, reports, and logs. Include standard reports for the following:

1) Current values of all objects.
2) Current alarm summary.
3) Disabled objects.
4) Alarm lockout objects.
5) Logs.

n. Custom report development.
o. Utility and weather reports.
p. Workstation application editors for controllers and schedules.
q. Maintenance management.

2. Custom Application Software:

a. English language oriented.
b. Full-screen character editor/programming environment.
c. Allow development of independently executing program modules with debugging/simulation capability.
d. Support conditional statements.
e. Support floating-point arithmetic with mathematic functions.
f. Contains predefined time variables.

2.4 BUILDING MANAGEMENT CONTROL SYSTEM

A. The Building Management Control System (BMCS) shall consist of an information sharing network of stand-alone Direct Digital Control Panels (DDCP's).

B. "Information sharing" shall be defined as: the function of each DDCP to exchange data on the network trunk with other DDCP's without the need for additional devices such as gateways or central computers.

C. "Stand-alone" shall be defined as: the function of each DDCP to independently monitor and control connected equipment through its own microcomputer.

D. All control devices will be electronic.

2.5 BUILDING CONTROLLER – GLOBAL (BCM)

A. All communication with operator workstation and all programmable controllers shall be via BACnet. Building controller shall incorporate as a minimum, the functions of a 3-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz), at least 4 master slave token passing (MS/TP) LANs, a point-to-point (PTP – RS-232) connection and an on-board modem.

1. Each MS/TP LAN must be software configurable for ARCNET156kbps or BACnet MS/Tp 9.6 to 76.8Kbps.
2. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).
3. The direct access port must be a female DB-9 connector supporting BACnet temporary PTP connection of a portable BACnet operator terminal at 9.6 to 115.2 Kbps over RS-232 null modem cable.
4. Building controller shall be capable of providing global control strategies for the system based on information from any objects in the system regardless if the object is directly monitored by the controller or by another controller. The program that implements these strategies shall be completely flexible and user definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable.
5. Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values... All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be resident on workstation and the same tool used for all controllers.
6. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.
7. Building controller shall provide battery-backed real-time (hardware) clock functions.
8. Controller shall have a memory needed to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative).
9. Global control algorithms and automated control functions should execute via 32-bit processor.
10. Controller installation shall include memory-free gel-cell battery providing ongoing power conditioning and noise filtering for operation data integrity. It shall provide up to 5 minutes of powerless operation for orderly shutdown and data backup.

B. BACnet Conformance:

1. Building Controller shall as a minimum support Point-to-Point (PTP), MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a native BACnet device and shall support simultaneous routing

functions between all supported LAN types. Global controller shall be a BACnet Conformance Class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

a. Clock Functional Group
b. Files Functional Group
c. Reinitialize Functional Group
d. Device Communications Functional Group
e. Event Initiation Functional Group

2. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. The Building Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internet work, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).

C. Remote Communications:

1. Provide all functions that will allow remote communications via the Owner's Intranet to off-site locations.
2. Utilize IT Standard Netscape or Internet Explorer that allows operator to view and change all information associated with system on color graphic displays. Operator shall be able to change all parameters in this section from off-site location including all programming of building controllers and all programmable controllers including all terminal unit controllers. No priority software required.
3. Building controller shall have capability to call out alarm conditions automatically. If desired, controller may also send encoded message to digital pager. If an alphanumeric pager is in use by the operator, building controller shall be capable of sending a text or numeric string of alarm description. All building controllers connected to the local LAN shall be capable of calling out alarm messages through one or more shared modems connected to one or more of the building controllers on the local LAN.
4. Building controller shall have capability to call a minimum of 20 different phone numbers. Numbers called may be controlled by type of alarm or time schedule.
5. Owner shall provide standard voice-grade phone line for remote communication function.
6. Building controller and internal modem shall be capable of modem-to-modem baud rates of 33.6 Kbps minimum over standard voice-grade phone lines. Lower baud rates shall be selectable for areas where local phone company conditions require them.

D. Schedules: Each building controller shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.

E. Logging Capabilities:

1. Each building controller shall log as minimum 1000 trend logs. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
2. Logs may be viewed either on-site or off-site via remote communication.
3. Building controller shall periodically upload trended data to networked existing site server for long term archiving if desired.
4. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

F. Alarm Generation:

1. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
2. Each alarm may be communicated as noted above.
3. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
4. Controller must be able to handle up to 1500 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

2.6 DISTRIBUTED CONTROL PANEL (DDCP)

A. The system shall utilize intelligent distributed digital control panels (DDCP) to interface with sensors being monitored and equipment being controlled by the building management and control systems. Provide one or more BACnet or LonWorks programmable controllers for each air handler and provide BACnet or LonWorks programmable controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on existing site server and be the same tool as used for the building controller and remain on the server. No auxiliary or non-BACnet controllers shall be used. Proprietary protocols will not be accepted.

B. BACnet Conformance:

1. Controllers shall as a minimum support MS/TP BACnet and/or LonWorks LAN types. They shall communicate directly via these LAN's at 76.8 Kbps or higher,

as BACnet/LonMark devices. Controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

a. Files Functional Group
b. Reinitialize Functional Group
c. Device Communications Functional Group

C. Controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0–10VDC, 0–5 VDC, 4–20 mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of 3 inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0–10VDC or 0–20mA. Software shall include scaling features for analog outputs. Application controller shall include 24VDC voltage supply for use as power supply to external sensors.

D. Each DDCP shall execute all application programs, calculations and commands via a 16-bit microcomputer resident in the panel. The microcomputer shall permit floating point calculations to enable the performance of energy calculations.

E. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Controller shall execute all program sequences 10 times per second and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal. Programming of application controller shall be completely modifiable in the field through the site server with no additional tools required. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen.

F. Each DDCP shall be capable of full operation either as a completely independent panel or as a part of the existing building-wide control system. All panels shall contain the necessary equipment for direct interface to the sensors and actuators connected to it. The DDCP network shall be able to detect changes in any DDC panel point status and report these changes to all terminals accessing the building-wide network.

G. Each DDCP shall include its own microcomputer direct digital controller, power supply, input/output modules, communications board, two (2) RS-232 communications port, and battery. The DDCP shall have built-in diagnostics to display at any operator's terminal the amount of available RAM in each DDCP on the network. Each DDCP shall perform continuous diagnostics, and any malfunction shall be annunciated at the operator's console as well as visually indicated at the DDC panel.

H. Failure of any DDCP on the system shall not affect the proper operation of the remaining system components.

I. The system shall be capable of phased start-up. That is, any DDCP shall be capable of properly communicating with the rest of the system while remaining panels are being installed.

J. UL Listings for each DDCP shall be UL916 (Energy Management Systems),. Units shall be tested to comply with sub-part J of Part 15 FCC rules for Class A computing equipment.

K. Cabinet for each DDCP shall be all metal construction NEMA 1 construction. Each panel, including cabinet, power supply, function cards and termination modules, shall be UL approved. Each panel shall have a pin-hinged door and master keyed lock.

L. Each DDCP shall be capable of proper operation in an ambient environment of 32 to 120 degrees F and 10 to 90% RH.

M. The DDCP shall be furnished with a user programmable language and internal memory of at least 128Kb RAM for local storage of extended trend data.

N. Controller shall include support for intelligent room sensor. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.7 DDCP PROGRAMMING FUNCTIONS

A. Resident software in the DDCP shall provide for custom programming of control strategies, point database, operator interface, network communications, facilities and energy management functions.

B. Programming of control and energy management strategies shall be accomplished via logic block programming. A standard math processor shall be part of the programming language. All analog loops shall be capable of proportional, integral, and derivative control.

C. Operator Interface Program (OIP) that allows an English language user interface shall be provided with each DDCP. The OIP shall allow the user to program, interrogate, command and edit future DDCP's that may be added to the network via a self-prompting method. Operator terminals, whether textual or graphical, shall be able to access any future network additions from any DDCP and any DDCP within the existing facility. Access shall be accomplished in a transparent fashion; that is, the operator shall not be required to address specific DDCP's in order to display or command system points.

2.8 USER PROGRAMMABILITY

A. All temperature control strategies and energy management routines shall be definable by the operator through an operator interface device connected to any DDCP using logic block diagrams. The system shall be provided complete with all equipment, software and documentation necessary to allow a trained operator to independently perform the functions listed below.

1. Read the value of a measure variable (i.e., temperature).
2. Start or stop equipment.
3. Monitor the status of equipment being controlled.
4. Read the set point of a control loop.
5. Determine the control strategies that have been defined for a specific piece of equipment.
6. Generate displays of control strategies.
7. Add/delete control loops to the system.
8. Add/delete points to the system.
9. Create, modify or delete control strategies using logic block diagram programming.
10. Assign sensors and/or actuators to a control strategy.
11. Tune control loops through the adjustment of control loop parameters.
12. Enable or disable control strategies.
13. Select points to be alarmable and define the alarm state(s).

2.9 SELF-DIAGNOSTICS AND ALARM REPORTING

A. Self-diagnostics that continuously monitor the proper operation of each DDCP unit shall be built into each unit. A malfunction of the DDCP shall be reported, and shall inform the operator of the nature of the malfunction and the panel affected. It shall be possible to annunciate malfunctions as well as other DDCP alarms at a selected operator's terminal.

B. Provide on-line diagnosis and system interaction via telephone modem from a remote location through the use of a work station terminal or portable operator terminal.

2.10 DDCP SOFTWARE

A. Each DDCP shall be capable of independently performing the following control and energy management routines as a minimum:

1. Time of day scheduling.
2. Start/stop time optimization.
3. Economizer control.
4. Enthalpy changeover.
5. Demand controlled ventilation.

6. Supply air temperature reset.
7. Outdoor air reset.
8. Chilled & Hot water temperature reset.
9. Event initiated programs.
10. Trending.
11. Power demand limiting.

B. In addition, each DDCP unit shall independently support the creation and modification of custom direct control algorithms based on arithmetic, Boolean or time-based logic. Each panel shall support the creation, modification or removal of control algorithms while operating. Such functions shall be programmed using a sequential, numbered-statement programming language. Each control loop shall be fully user definable as follows:

1. Sensors and actuators.
2. Control mode (proportional, integral, derivative, or combinations thereof).
3. Gains.
4. Control action.
5. Sampling time.

C. All temperature control functions shall be executed within the DDCP. Loop control shall be executed via direct digital control algorithms. The user shall be able to customize control strategies and sequences on control and shall be able to define appropriate control loop algorithms and choose the optimum loop parameters for loop control. All control loops provided under this contract shall be properly tuned P.I.D. control loops. If the network communication link fails or the other DDCP malfunctions, the control loop shall continue to function using the last value received from the DDCP.

D. The system shall allow custom control algorithms to be created locally within the DDCP via a portable-operator terminal, and centrally in the central console.

E. Resident software, which allows user interface using simple menus and single letter commands shall be, supplied standard with each DDCP. This software shall require the operator to have knowledge of specific point addresses or other such system-specific information to allow access. Solutions, which require basic user interface software to be resident in personal computers or other extra devices, will not be acceptable.

F. The system shall permit the generation of the job- specific control strategies that can be activated in any of the following ways:

1. Continuously.
2. At a particular time of day.
3. When a specific measured or controlled variable reads a selected value or state.
4. When a piece of equipment has run a certain period of time.

2.11 TERMINAL EQUIPMENT CONTROLLER

A. Equipment includes VAV boxes, unit ventilators, fan coils, cabinet unit heaters, unit heaters, etc.

B. Provide one native BACnet terminal equipment controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit. Controllers will be fully programmable. Controllers that are not fully programmable such as “Configurable” Application Specific will not be accepted.

C. BACnet Conformance:

1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

    a. Files Functional Group
    b. Reinitialize Functional Group
    c. Device Communications Functional Group

2. Standard BACnet object types supported shall include as a minimum–Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

E. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

F. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs to each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal Equipment Controllers utilizing proprietary control signals and actuators shall not be acceptable.

G. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

1. Accuracy: =/- 0.5 degrees F (=/- 0.3 degrees C)
2. Operating Range: 35 degrees to 115 degrees F (2 degrees to 46 degrees C)
3. Set Point Adjustment Range: 55 degrees to 95 degrees F (2 degrees to 30 degrees C)
4. Set Point Modes: Independent Heating, Cooling, Night Setback-Heating, Night Setback - Cooling
5. Calibration Adjustments: None required
6. Installation: Up to 100 ft from controller

H. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable laptop or similar operator's terminal to control and monitor all hardware and software points associated with the controller. In lieu of an internal jack, provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.

I. Each room sensor shall also include the following auxiliary devices:

1. Setpoint Adjustment
2. Override Switch

J. The setpoint adjustment shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation, DDCP or via the portable programming tool. In lieu of an integral adjustment dial, provide a separate dial mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

K. The override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDCP or via the portable programming tool. In lieu of an integral switch, provide a separate momentary contact switch mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

L. Each controller shall perform its primary control function independent of other DDCP network communication, or if network communication is interrupted. Reversion to a fail-safe mode of operation during network interruption is not acceptable. Should the controller reside on a DDCP network, the controller shall receive its real-time data from the DDCP clock to insure network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

M. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this powerful protection requirement. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

N. Each controller shall have connection provisions for a portable laptop or similar operator's terminal. This connection shall be possible at either the controller or at the matching room temperature sensors as previously specified. The terminal may be used for readout of system variables, override control, adjustment of control parameters, air balancing, servicing and troubleshooting. The terminal shall provide the user with the following functionality as a minimum:

1. Display system status (heating, cooling, etc.)
2. Display all point values and setpoints
3. Set and change all setpoints
4. Set and change heating/cooling deadbands
5. Set and change PID loop gains
6. Set and change system mode (occupied/unoccupied)
7. Set and change system mode lines
8. Override all setpoints
9. Override all digital and analog outputs
10. Command all digital and analog outputs
11. Select application mode
12. Assign controller address

O. All communication and displays via the portable terminal shall be in full English language with accompanying English and SI (International System of Units) engineering units for all displayed data. Selection between English and SI units shall be accomplished via a single keystroke on the portable terminal.

P. In addition to local interface capabilities, all functionality as specified above may be performed both from the central operator's workstation and from any DDCP on the communications network via the same portable terminal. From a terminal connected to any DDCP it shall be possible to issue global commands to groups of controllers. Provide the following global commanding capabilities for all controllers as a minimum:

1. Start/Stop of all terminal unit fans.
2. Heating/Cooling setpoint changes.
3. Modulate Open/Closed all valves in percent open notation.
4. Modulate Open/Closed all dampers in percent open notation.
5. Minimum/Maximum CFM setpoint changes (terminal box controllers).

Q. Unitary Controllers shall support the following types of point inputs and outputs:

1. Economizer Switchover Inputs

    a. Dry bulb
    b. Outdoor Air Enthalpy
    c. Differential Temperature
    d. Binary Input from a separate controller

2. Economizer Outputs

    a. Integrated Analog with minimum position
    b. Binary output to enable self-contained economizer actuator

3. Heating and Cooling Outputs

    a. 1 to 3 Stages
    b. Analog Output with two-pipe logic
    c. Reversing valve logic for Heat Pumps

4. Fan Output

    a. On/Off Logic Control

R. Controllers shall support the following library of control strategies to address the requirements of the sequences described in the "Execution" portion of this specification, and for future expansion:

1. Daily Schedules
2. Comfort/Occupancy Mode
3. Economy Mode

    a. Standby Mode/Economizer Available
    b. Unoccupied Mode/Economizer Not Available
    c. Shutdown

4. Lighting Logic Interlock to Economy Mode
5. Temporary Override Mode

    a. Temporary Comfort Mode (Occupancy-Based Control)
    b. Boost (Occupant Warmer/Cooler Control)

S. Occupancy-Based Economy/Comfort Mode Control: Each Unitary Controller shall have a provision for occupancy sensing overrides. Based upon the contact status of either a manual wall switch or an occupancy sensing device, the Unitary Controller shall automatically select either an Economy or Comfort mode.

T. Temporary Override Modes:

1. Temporary Occupancy Mode: The controller interface to the zone temperature sensor shall allow for an optional momentary switch to change the mode of the controller from economy to comfort and optionally interlock the room lights for a preset amount of time.
2. Boost Mode: The controller interface to the zone temperature sensor shall allow for an optional momentary switch to override the controller's output to full heating or cooling. This command shall be active for a preset amount of time, to anticipate substantial change in the room's load.

U. Continuous Zone Temperature Histories: Each Unitary Controller shall automatically and continuously maintain a history of the associated zone temperature. This allows users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

V. Alarm Management: Each Unitary Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2.12 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Accuracy: Plus or minus 0.5 degrees F at calibration point.
2. Wire: Twisted, shielded-pair cable.
3. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than nine (9) sq ft.
4. Averaging Elements in Ducts: 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq ft.
5. Insertion Elements for Liquids: Brass or stainless steel socket with minimum insertion length of 2-1/2 inches.

6. Room Sensor Cover Construction: Manufacturer's standard locking covers.

    a. Set-Point Adjustment: Local adjustment provided at each temperature sensor unless in “public” areas such as hallways, foyers or bathrooms. All adjustments will be limited by software for upper and lower setpoint limits.
    b. Timed Override: Each sensor will provide a local “timed override” button to allow the associated zone to be placed in “Occupied” mode for a programmed period of time. This feature will not be provided in “public” areas such as hallways, foyers or bathrooms.
    c. Set-Point Indication: Concealed.
    d. Thermometer: Concealed.
    e. Orientation: Vertical.

7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
8. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.

C. RTDs and Transmitters:

1. Accuracy: Plus or minus 0.2 percent at calibration point.
2. Wire: Twisted, shielded-pair cable.
3. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than nine (9) sq ft.
4. Averaging Elements in Ducts: 24 feet long, flexible; use where prone to temperature stratification or where ducts are larger than nine (9) sq ft; length as required.
5. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
6. Room Sensor Cover Construction: Manufacturer's standard locking covers.

    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Concealed.
    c. Thermometer: Concealed.
    d. Color: Color to be determined by Architect.
    e. Orientation: Vertical or Horizontal.

7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
8. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

D. Humidity Sensors: Bulk polymer sensor element.

1. Accuracy: Two (2) percent full range with linear output.
2. Room Sensor Range: 20 to 80 percent relative humidity.
3. Room Sensor Cover Construction: Manufacturer's standard locking covers.

    a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Concealed.
c. Thermometer: Concealed.
d. Color: Color to be determined by Architect.
e. Orientation: Vertical or Horizontal.

4. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
5. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 degrees F.
6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: Two (2) percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Building Static-Pressure Range: 0- to 0.25-inch wg.
d. Duct Static-Pressure Range: 0- to 5-inch wg.

2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.13 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and one (1) percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum two (2) percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.14 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. Honeywell International Inc.; Home & Building Control.
2. INTEC Controls, Inc.
3. Vulcain Inc.
4. KELE Inc.
5. Veris Industries

B. Carbon Monoxide (CO) Detectors: Single or multi-channel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 degrees F; with two (2) factory-calibrated alarm levels at 50 and 100 ppm.

1. CO detectors (sensors/transmitters) shall be installed, tested and maintained in strict accordance with the CO detector manufacturer's instructions and with NFPA 720. Additionally, the CO detectors shall be mounted as remotely from the heating appliance, as possible, within the space.
2. CO detectors (sensors/transmitters) shall be in compliance with ANSI/UL 2075. Also, gas and vapor detectors (sensors/transmitters) shall meet the sensitivity tests and alarm thresholds of ANSI/UL 2034, the standard for single and multiple station carbon monoxide alarms.

C. Carbon Dioxide (CO_2) Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 degrees F and

calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.

2.15 FLOW MEASURING STATIONS

A. Duct Mounted Configurations

1. Approved manufacturers:

   a. Air Monitor Corporation: VOLU-probe or ELECTRA-flo/Plus
   b. Ebtron Inc.: Advantage II Gold Series

2. Provide either pitot type or thermal type air flow measuring system for ducted applications as specified below.
3. Installation locations shall comply with manufacturer's recommended straight lengths of duct upstream and downstream of station.

   a. Provide open parallel cell air straightener–equalizer honeycomb upstream of station, where required, to meet manufacturer's straight length recommendations. Honeycomb and probes to be mounted in 14 ga. (minimum) galvanized steel, welded casing in 8" depth with 90º connecting flanges in a configuration and size equal to that of the duct it is mounted into

4. Pitot type airflow measuring system

   a. Each airflow traverse probe shall contain multiple total and static pressure sensors located along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. The flow sensors shall not protrude beyond the surface of the probe(s), and shall be the offset (Fechheimer) type for static pressure and the chamfered impact type for total pressure measurement. The airflow sensing probe's measurement accuracy shall not be affected by directional flow having pitch and/or yaw angles up to 30º. Each airflow traverse probe shall be of extruded aluminum construction and furnished with mounting plate(s), gasket, and signal fittings suitable for HVAC duct installation.
   b. Total and static pressure sensors shall be located at the centers of equal areas (for rectangular ducts) or at equal concentric area centers (for circular ducts) along the probe length.
   c. Probes shall be AMCA certified and be capable of measuring the airflow rates within an accuracy of ±2% without the use of correction factors. The maximum allowable unrecovered pressure drop caused by the probes shall not exceed .025" w.c. at 2000 FPM, or .085" w.c. at 4000 FPM.

d. The Transmitter shall have an accuracy of ±0.5% of Natural Span and user selectable square root function. The Transmitter shall be housed in a NEMA 1 aluminum with universal 1/8" FPT signal connection ports.

5. Thermal type airflow measuring system

a. Each probe array shall consist of one or more multi-point measuring probes and a single microprocessor based transmitter. The transmitter shall be supplied by the same manufacturer as the measuring station or probe array.
b. Each multi-point probe shall be assembled using heavy wall anodized aluminum tubing, aluminum mounting plates, aerodynamically optimized molded sensing apertures to ensure accurate measurement in angular airflow conditions, and neoprene mounting gasket.
c. The probe array shall be connected to the transmitter using a single cable, of up to 100' in length, included with the transmitter.
d. Each stand-alone sensing point shall use an ambient temperature thermistor and an externally heated thermistor to determine the point velocity and temperature. Automatic equal area averaging of the individual point measurements shall be performed in the transmitter.
e. Each airflow sensor shall have an operating range of 5,000 FPM, with a NIST traceable accuracy of ±2% of reading for velocity measurement and 0.1ºF for temperature measurement.
f. The number of sensors for each rectangular probe array shall be:

Station Area	Sensor Density
1 to < 15 Sq. Ft.	1.50 Sq. Ft. Per Sensor
15 to < 30 Sq. Ft.	1.67 Sq. Ft. Per Sensor
30 to < 60 Sq. Ft.	2.10 Sq. Ft. Per Sensor
60 to 100 Sq. Ft.	3.13 Sq. Ft. Per Sensor

g. Individual sensors shall be fully field serviceable without need for field calibration, not requiring that the probe be returned to the Factory for repair and/or calibration.
h. Each transmitter shall be capable of averaging as many as thirty-two (32) sensors,
i. The transmitter will have a high visibility backlit LCD for display of either the averaged or individual sensor airflow and temperature measurements, in user selectable units of measure. The transmitter shall be factory configured to output duct air volume for plug and play operation.
j. All transmitter configuration, scaling, and diagnostic functions shall be performed by means of a password protected, cover mounted membrane keypad.

k. The transmitter outputs shall be dual analog (4-20mA, 0-5VDC or 0-10VDC) for airflow and temperature or optional LonWorks® communication interface.
l. The operating temperature range of the transmitter shall be from -20º to 140ºF. The transmitter shall be located where it will be sheltered from water or weather.
m. Input power to each transmitter shall be 24VAC/24VDC.
n. When installed per the manufacturer's minimum installation requirements, the transmitter with accompanying station or probe array shall measure with an accuracy of ±2-3% of actual flow.

B. Fan Inlet Configurations

1. Approved manufacturers:

a. Air Monitor Corporation: VOLU-probe/FI
b. Ebtron Inc.

2. Provide only pitot type air flow measuring systems for fan inlet configurations.
3. The Airflow Measuring Station shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probes and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
4. The Airflow Measuring Station shall have symmetrical averaging signal takeoffs, and shall be of aluminum construction with hard anodized finish [copper construction] with galvanized steel mounting hardware.
5. The Airflow Measuring Station shall not significantly impact fan performance or contribute to fan generated noise levels. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.
6. The Transmitter shall have an accuracy of ±0.5% of Natural Span and user selectable square root function. The Transmitter shall be housed in a NEMA 1 aluminum enclosure with universal 1/8" FPT signal connection ports.

C. Outside Airflow Configurations

1. Approved manufacturers:

a. Air Monitor Corporation: VOLU-flo/OAM
b. Ebtron Inc.

2. The outside air flow measuring station shall be constructed to prevent measurement instability caused by the variable presence of moisture (rain and

humidity), and accuracy degradation caused by dirt build-up around flow station ports and thermal surfaces.

3. The outside airflow measuring station shall obtain accurate and repeatable measurement in the absence of any upstream/downstream straight duct run.
4. The outside air flow measuring station shall account for outside air temperature variances of 150° F installed in locations ranging from sea level to 5,000 feet elevation. The station shall make necessary temperature and altitude compensating adjustments.
5. The outside air flow station shall use a technology that measures pressure drop via an outside air reference and an inlet airflow sensor across a fixed resistance element to provide 5 % accuracy for outside air under all circumstances. The Outside Reference Sensor shall be centrally positioned in, and mounted to the surface of the inlet. The Reference shall be located upstream of any inlet louver, mist eliminator, bird screen, rain hood, etc. The Inlet Airflow Sensor shall be located downstream of any inlet louver, mist eliminator, bird screen, rainhood, etc., and upstream of the outside air intake control damper(s). Outside airflow sensors that use technologies other than pressure drop (thermal or pitot tube) shall provide the means to protect the flow station from moisture and provide a means to clean to unit from dirt and debris on a continuous basis.
6. The Outside Airflow Measurement System shall contain an integral multi-line liquid crystal display for use during the configuration and calibration processes, and to display two measured processes (volume, velocity, temperature) during normal operation. All configuration, output scaling, calibration, and controller tuning will be performed digitally in the on-board microprocessor via input pushbuttons
7. The Outside Airflow Measurement System shall measure inlet airflow with an accuracy of ±5% of reading over a range of 150-600 FPM, 250-1,000 FPM, 150-2,000 FPM, and 500-2,000 FPM and not have its reading affected by the presence of directional or gusting wind. Measured airflow shall be density corrected for ambient temperature variances, and atmospheric pressure due to site altitude.
8. The outside air flow measuring station shall be constructed to prevent measurement instability caused by the variable presence of moisture (rain and humidity), and accuracy degradation caused by dirt build-up around flow station ports and thermal surfaces.
9. The Outside Airflow Measurement System shall interface with existing building automation systems (BAS), accepting inputs for fan system start, economizer mode operation, and an external controller setpoint, and provide flow deviation alarm outputs.
10. The sensors shall be constructed of materials that resist corrosion due to the presence of salt or chemicals in the air; all non-painted surfaces shall be constructed of stainless steel. The electronics enclosure shall be NEMA 1.

    a. If the electronics enclosure is to be mounted outdoors, provide in a thermostatically controlled NEMA 4 enclosure with heater

2.16 THERMOSTATS

A. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF" to suit sequence of operations for respective system.
2. Mount on single electric switch box.

B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 degrees F set-point range, and four (4) degrees F maximum differential. Units shall not have a local readout.

1. For thermostats located in the classrooms, provide thermostats with limited ability by occupants to adjust the temperature setpoint by ±4°F (adj.).

C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 degrees F set-point range, and four (4) degrees F maximum differential. Units shall not have a local readout.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

D. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

E. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 degrees F above normal maximum operating temperature, and the following:

1. Reset: Manual.

F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

G. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

H. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq ft of coil surface.

I. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq ft of coil surface.

J. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.

2.17 HUMIDISTATS

A. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, two (2) percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.18 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 23 05 13.
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

3. Non-spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in x lbf.
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in x lbf.
5. Non-spring-Return Motors for Dampers Larger Than 25 Sq Ft: Size for running torque of 150 in x lbf and breakaway torque of 300 in x lbf.
6. Spring-Return Motors for Dampers Larger Than 25 Sq Ft: Size for running and breakaway torque of 150 in x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: Seven (7) inch-lb/sq ft of damper.
    b. Opposed-Blade Damper with Edge Seals: Five (5) inch-lb/sq ft of damper.
    c. Parallel-Blade Damper without Edge Seals: Four (4) inch-lb/sq ft of damper.
    d. Opposed-Blade Damper without Edge Seals: Three (3) inch-lb/sq ft of damper.
    e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24-V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA,
9. Temperature Rating: Minus 22 to plus 122 degrees F.
10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 degrees F.
11. Run Time: 12 seconds open, 5 seconds closed.
12. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 degrees F unless located in return-air plenums.

2.19 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:

    a. Two (2) Position: Line size.
    b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

C. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A126 cast-iron or ASTM A536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer, Lug or Grooved.
2. Disc Type: Nickel-plated ductile iron.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 degrees F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

E. Self-Contained Control Valves: Bronze body, bronze trim, two (2) or three (3) ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 degrees F operating conditions.
2. Thermostatic Operator: Liquid-filled remote sensor with remote adjustable dial.

2.20 DAMPERS

A. Dampers: Class I, AMCA-rated, opposed-blade design; 0.108-inch minimum thick, galvanized-steel or 0.125-inch minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch thick galvanized steel with maximum blade width of eight (8) inches and length of 48 inches.

1. Secure blades to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 degrees F.
3. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq ft of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.21 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 27 15 00.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with drawings and room details before installation. Install devices in accordance with the latest ADA requirements, above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Gynasiums
4. Where indicated.

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. When installing low limit temperature sensors/transmitters in air handling equipment located outdoors, install the controllers in warm areas, not in locations exposed to outdoor temperatures. To avoid false readings and nuisance trips, provide insulation on any section of the sensing bulb that must travel through an area that may be subjected to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Section 23 05 53.

H. Install electronic and fiber-optic cables according to Section 27 15 00.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 26 05 33.

B. Install building wire and cable according to Section 26 05 19.

C. Install signal and communication cable according to Sections 27 13 00 and 27 15 00.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Document all results of inspections, testing, adjusting and verification in a report and submit to Architect/Engineer for record.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check temperature instruments and material and length of sensing elements.
6. Check control valves. Verify that they are in correct direction.
7. Check dampers - Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to project during other than normal occupancy hours for this purpose.

3.6 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer’s written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer’s written instructions/requirements.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 40 hours to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Control sequences for HVAC systems, subsystems, and equipment.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 16 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 03 - Building Commissioning Requirements.

F. Section 23 08 00 - Commissioning of HVAC.

G. Section 23 09 00 - Instrumentation and Control for HVAC: Control equipment and devices and for submittal requirements.

H. Section 23 81 24 - Split AC Systems.

I. Section 26 51 00 - Interior Lighting.

J. Section 26 56 00 - Exterior Lighting.

1.4 GENERAL

A. Unless noted otherwise herein, all control functions described herein shall be accomplished via a DDC building management control system, herein referred to as the BMCS. All devices, low and line voltage wiring, hardware, software, etc… necessary to accomplish the control functions shall be provided by the BMCS

contractor, unless noted otherwise. Where there are any deviations of the submitted and approved equipment that results in the inability to perform of any of the sequencing indicated herein and in other Div. 23 documentation, the BMCS contractor shall clearly indicate the deficiency in the submittals and if applicable, provide a solution to compensate for the lack of control.

B. Where any packaged mechanical equipment is equipped with factory installed controls (i.e. AHUs, RTUs, MAUs, Chillers, Boilers, CRACs, ACs, HX, C, etc…), or external control systems that are furnished for field installation, the BMCS contractor shall coordinate with the mechanical equipment vendors and all approved equipments submittals to ensure compatibility with the BMCS and to provide the level of control indicated herein and in other Div. 23 documentation. The BMCS contractor shall provide all components (line voltage wiring, low voltage wiring, controllers, etc…) necessary to support the installation of shipped loose control components from the equipment manufacturers.

C. All setpoints described in this sequence of operation shall be fully adjustable throughout the entire range of the sensors being used to measure the variable being controlled. All controlled variables identified in the following sequence of operation shall be maintained at setpoint using proportional-integral control algorithms, in order to ensure that no error exists between the controlled variable and its setpoint at steady-state conditions. Proportional-integral-derivative algorithms shall be used if the process so warrants, at the discretion of the control software programmer.

D. Point Lists provided in the Sequence are a minimum and should be used as a guideline. All points listed are required. Any additional points required meeting the sequence of operations or the specification or the intent of the specification will be included.

E. The new BMCS shall be capable of connecting, via web-access, to the Owner's existing remote central BMCS to allow for full remote operation of all of the new HVAC equipment from the existing BMCS. The BMCS contractor shall coordinate with the Owner's representative.

1. The BMCS contractor shall provide all additional new software, hardware, programming, wiring/cable, etc. to achieve the connection between the new and existing BMCS.

F. Alarms will be set up initially by the BMCS contractor. The system will be capable of unlimited alarms. Any alarms that the customer requests to be set up will be done by the contractor at no additional charge. All alarms shall be annunciated, visually and audibly, locally and at the BMCS within the building and remotely at the central BMCS.

G. The BMCS contractor shall be responsible for control and monitoring as follows:

1. Division 22: Domestic Hot Water Recirculation Pumps.
2. Division 23:

a. Roof Mounted Air Handling Units (AHUs)
b. Rooftop Air Conditioning Units (RTUs)
c. Computer-Room Air-Conditioners (CRACs)
d. Split System Air-Conditioners & Air-cooled Condensing Units (ACs & ACCUs)
e. Make-up Air Units (MUAs)
f. Steam – Hot Water Convertors (Cs)
g. Hot Water Pumps (Ps)
h. Variable Air Volume Terminal Units (VAVs)
i. Kitchen & Servery Hood Exhaust Systems (KHE & SHE)
j. Miscellaneous Exhaust Fans (EFs)
k. Hot Water Fintube (FT)

3. Division 26: Lighting Control – Indoors and Outdoors.
4. Provide all necessary devices, wiring – line & low voltages, hardware, software, etc… for limited complete control and monitoring of these systems in accordance with the requirements indicated in their respective contract documentation. Coordinate with the work by all related Divisions.

1.5 HOT WATER HEATING SYSTEM

A. General:

1. The hot water heating system, herein referred to as “the system”, consists of the convertor, C-1, and the system distribution pumps, P-1 & 2. The system will be a skid-mounted with all electrical components factory, mounted, and wired. The BMCS contractor shall provide all controls (i.e. low voltage wiring, devices, hardware, software, etc…) necessary to achieve the operations described herein.
2. Hot water shall be available during the winter only. The system will be enabled, manually or automatically, through the BMCS. When the building “winter mode” is enabled, the system will be indexed into “heating mode”.
3. The system distribution pumps, P-1 & 2, shall be setup for lead/standby. The distribution pumping operation shall be variable primary.
4. The runtimes of the pumps shall be monitored and the lead pump shall be cycled on a weekly basis (adj.). The lead pump shall be determined based on the unit with the least runtime.

B. System operation: Once the system in enabled, it shall be controlled as follows:

1. The lead variable volume distribution pump will start and operate continuously. The pump shall operate through its variable frequency drive (VFD), under the control of the BMCS.

a. If the lead distribution pump fails to operate as sensed by a differential flow switch the lead distribution pump shall be disabled. The BMCS shall

enable the stand-by pump. An alarm shall be sent to the OWS indicating the failed pump. The alarm shall be manually reset.

1) If at any point, all pumps fail to prove as running, all pumps shall be disabled and a critical "NO HEAT" alarm will be annunciated at the OWS. The alarm shall be manually reset.

b. The BMCS shall modulate the distribution pump speed through the VFD to maintain a differential pressure setpoint. Each pump shall be provided with its own VFD and wired independently of each other.

1) A differential pressure transmitter (DPT) will be provided to sense the differential pressure. The transmitter shall be located in an hydraulically remote location (traditionally, 2/3rds downstream), between the system's distribution pump and the farthest point of the piping distribution. The BMCS contractor, in cooperation with the TAB Contractor, shall coordinate final location. Coordinate with the TAB Contractor to determine the diff. pressure setpoint, based on actual conditions, once the system has been finally balanced.
2) If the DPT fails, the BMCS will continue to operate the system using the last known differential value just prior to when the failure occurred and an advisory signal shall be sent to the OWS.

2. Once water flow has been established, the BMCS shall modulate the steam control valve to maintain the hot water supply (HWS) temperature setpoint. When the system HWS temperature rises above its setpoint, the reverse shall occur.

a. The system HWS temperature setpoint shall be provided with a ±5°F deadband (adj.) to minimize excessive valve modulation.
b. The system HWS temperature shall be reset to maintain the hot water temperature reset schedule indicated on the drawings.

POINT LIST:		Alarms to be set up by ATC:
AI	Hot Water Supply Temp.	Alarm on failure or +/- 4 degrees of setpoint
AI	Hot Water Return Temp.	Alarm on failure or +/- 4 degrees of setpoint
AI	Supply (High) Pressure	Must be separate from Return
AI	Return (Low) Pressure	Must be separate from Supply (Subtract)
AO	1/3 Control Valve	
AO	2/3 Control Valve	
AO	Hot Water Temperature Reset Setpoint	

DI	P-#, Pump Status	Alarm on Run Failure
DO	P-#, Start / Stop	
AO	P-#, VFD Speed	
DI	P-#, VFD Fault Status	Alarm on VFD Failure

1.1 AIR HANDLING UNITS (AHU-1 & 2)

A. General:

1. Unless specifically indicated otherwise, the following sequence of operations apply to all units.
2. The air handling units (AHU's) shall be manually or automatically indexed between Morning Warm Up/Cool Down, Occupied/Unoccupied and Summer/Winter modes through the BMCS.
3. The systems will not be allowed to index into the occupied mode simultaneously. They shall have an offset interval of a min. of (2) two minutes (adj.) between each unit.
4. The systems will operate in sequence providing the system safeties are satisfied.
5. The AHU's shall operate as follows:

    a. AHU-1 (Theater): Single Zone, Variable Volume, Variable Temperature.
    b. AHU-2 (Back-of-House): Multiple Zone, Variable Volume, Constant Temperature.

        1) The initial supply air temperature setpoint will be 55 degrees F, year-round. The supply air temperature shall be reset in response to the outdoor air temperature. Refer to the supply air temperature reset schedule located on the HVAC Flow & Control Diagrams.
        2) The AHU shall be controlled using a fan pressure optimization strategy. The system supply air static pressure setpoint shall be reset to the lowest possible, while still providing the required airflow to the zones with the greatest demand.

    c. The BMCS contractor shall detail the operation of these strategies and provide any additional items (i.e. programming, software, hardware, devices, line & low voltage wiring, etc…), not included herein, in order to assure intended system operations.

6. During the commissioning process, the BMCS contractor shall demonstrate the performance of all sequences herein.
7. Space/zone temperature sensors shall be provided a deadband of 5°F (adj.) within which the supply of heating and cooling energy to the zone is shut-off or reduced to a minimum. VAV terminal units shall be programmed to operate at

the minimum airflow setting without addition of reheat when the zone temperature is within the set deadband.

8. All setpoints will be adjustable.
9. All data points will have ability to be trended.
10. All data points may be alarmed.

B. Unoccupied Mode:

1. Space Temperature Setpoints:

   a. Summer – 85 degrees F (adj.)
   b. Winter – 60 degrees F (adj.)

2. Space Humidity Setpoint: 50% (adj.)
3. The supply and return fans shall be off, the outdoor and exhaust air dampers will be closed, and the return air damper will be open, and the chilled and hot water control valves shall be closed. All system safeties shall remain operational.

   a. During this mode, the supply air temperature reset and static pressure reset strategies will not be available.

4. The BMCS will monitor the following, to determine the critical space (AHU-2 Only):

   a. Space temperature and humidity sensors of all the associated spaces.
   b. The critical space shall be determined as follows:

      1) Winter mode: When any space temperature drops 2°F (adj.) below unoccupied setpoint.
      2) Summer Mode: When any space temperature rises 2°F (adj.) above unoccupied setpoint or when any space relative humidity rises 5% RH (adj.) above setpoint.

   c. The BMCS shall track multiple spaces that are considered critical, as defined above.

5. Temperature Control: Once the critical space is determined (AHU-2), or the room temperature sensor is not within setpoint (AHU-1), the following will occur:

   a. The supply fan will start and run at minimum airflow setting (adj.).

      1) AHU-1: The supply fan will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.
      2) AHU-2: will modulate to maintain the duct static pressure setpoint.

b. The OA damper will remain closed, unless the economizer sequence is active.
c. Warm Up: The hot water control valve will modulate to maintain the winter room temp. setpoint.
d. Cool Down: The economizer and/or chilled water control valve will modulate in sequence to maintain the summer space temp. setpoint.
e. Once all the space(s) are satisfied, the unit components shall revert back to the condition indicated in paragraph B, 3 above.

6. Humidity Control: Once the critical space is determined (AHU-2), or the room humidity sensor is not within setpoint (AHU-1), the following will occur:

a. The supply fan will start and run at minimum airflow setting (adj.).

1) AHU-1: The supply fan will index to minimum position and the speed will increase as needed to maintain the room humidity setpoint. The reverse will occur as room humidity is satisfied.
2) AHU-2 will modulate to maintain the duct static pressure setpoint.

b. The OA damper will remain closed, unless the economizer sequence is active.
c. The unit shall be indexed into the Humidity Control Mode.
d. Once the space(s) is satisfied, the unit components shall revert back to the condition indicated in paragraph B, 3 above.

C. Morning Warm Up/Cool Down: (The mode will be initiated by the BMCS through an optimal start calculation.)

1. The supply and return fans shall be off, the outdoor and exhaust air dampers will be closed, the return air damper will be open, and the chilled and hot water control valves shall be closed.

a. During this mode, the supply air temperature reset and static pressure reset strategies will not be available.

2. The BMCS will monitor the following, to determine the critical space (AHU-2 only):

a. Space temperature and humidity sensors of all the associated spaces.
b. The critical space shall be determined as follows:

1) Winter mode: When any space temperature drops 2°F (adj.) below occupied setpoint.
2) Summer Mode: When any space temperature rises 2°F (adj.) above occupied setpoint or when any space relative humidity rises 5% RH (adj.) above setpoint.

c. The BMCS shall track multiple spaces that are considered critical, as defined above.

3. Once the critical space is determined (AHU-2), or the room temperature sensor is not within setpoint (AHU-1), the following will occur:

   a. The supply fan will start and run at minimum airflow setting (adj.).

      1) AHU-1: The supply fan will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.
      2) AHU-2: will modulate to maintain the duct static pressure setpoint.

   b. The OA damper will remain closed, unless the economizer sequence is active.
   c. Warm Up: The hot water control valve will modulate to maintain the occupied, winter room temp. setpoint.
   d. Cool Down: The economizer and/or chilled water control valve will modulate in sequence to maintain the occupied, summer space temp. setpoint.
   e. When all space(s) are satisfied, the system will enter the occupied mode.

D. Occupied mode:

   1. Space Temperature Setpoints:

      a. Summer – 75 degrees F (adj.)
      b. Winter – 70 degrees F (adj.)

   2. Space Humidity Setpoint: 50% (adj.)
   3. The outdoor air (OA) damper will open and position to the outside air minimum CO_2 setpoint (Refer to AHU schedule for airflow quantity). The outside air shall be verified via the airflow monitoring station and indicated at the BMCS.
   4. The supply and return fans shall be enabled and run continuously. The fans shall run as follows:

      a. AHU-1:

         1) The supply fan will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.

      b. AHU-2:

         1) The supply fan speed will modulate to maintain the supply duct static pressure. The system static pressure setpoint shall be reset using the fan pressure optimization strategy.

c. The speed of the return fans (RF) will track the unit's supply airflow. The return fan airflow shall be equal to the supply airflow minus the CFM differential between the supply and exhaust airflows indicated on the AHU schedule to maintain building pressurization. All airflows shall be verified via the airflow monitoring station and indicated at the BMCS.

5. Cooling Mode:

   a. AHU-1: The economizer and chilled water control valve will modulate in sequence to maintain the room air temperature setpoint.
   b. AHU-2: The economizer and chilled water control valve will modulate in sequence to maintain the supply air temperature setpoint (55°F adj.). The supply air temperature shall be reset in response to the outdoor air temperature. Refer to the supply air temperature reset schedule located on the Mechanical Flow & Control Diagrams.
   c. Economizer Operation: When conditions are favorable (outside air enthalpy below return air enthalpy), the economizing sequence shall be active. The economizer shall be the primary stage of cooling.

6. Heating Mode:

   a. AHU-1: The economizer and hot water control valve will modulate in sequence to maintain the room temperature setpoint.
   b. AHU-2: The hot water control valve will modulate to maintain the supply air temperature setpoint (55°F adj.). The supply air temperature shall be reset in response to the outdoor air temperature. Refer to the supply air temperature reset schedule located on the Mechanical Flow & Control Diagrams.

E. Fan Pressure Optimization (Critical Zone Reset): (AHU-2 ONLY)

1. When any VAV damper is more than 75% (adj.) open, the supply fan discharge duct static pressure setpoint shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 15 min. (adj.), until no damper is more than 75% open or the static pressure setpoint has reset upward to the system maximum duct static pressure setpoint or the AHU variable-frequency drive is at the maximum speed setting.
2. When all VAV dampers are less than 65% (adj.) open, the supply fan discharge duct static pressure setpoint shall be reset downward by 0.1 in W.C. (adj.), at a frequency of 15 min. (adj.), until at least one damper is more than 65% open or the static pressure setpoint has reset downward to the system minimum duct static pressure setpoint or the AHU variable-frequency drive is at the minimum speed setting.
3. The control bands, setpoint increment values, setpoint decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.
4. The BMCS shall have the capability to allow the operator to exclude "problem" zones that should not be considered when determining the optimized setpoint.

5. The BMCS shall also read the status of the supply air static pressure sensor and display the active duct static pressure reading on the status screen.
6. The BMCS shall identify, and display at the OWS, the VAV box that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure setpoint optimization control.

F. Economizer Mode:

1. Economizer control will be based on enthalpy comparison. If the outdoor air enthalpy is lower than the return air enthalpy, the BMCS shall command the AHU into the economizer mode.

    a. The economizer mode shall override and take precedence over other modes of operation (i.e. CO_2 control).

2. When the AHU's are in economizer mode, the units shall operate as follows:

    a. The outside air damper and mechanical cooling will be controlled to maintain the room temperature setpoint in the following manner:

        1) Primary Stage: Mechanical cooling will be locked out and the OA damper will modulate between the CO_2 minimum setpoint position and 100% open (AHU supply airflow) to allow outdoor air to be delivered for free cooling.
        2) Secondary Stage: If the outdoor air damper reaches 100% open and the supply air temperature setpoint cannot be maintained using outdoor air alone, the outdoor air damper will be held 100% open and mechanical cooling will be enabled.

3. When the outdoor enthalpy rises above the return air enthalpy, the AHU shall return to its previous operating mode.

G. Humidity Control Mode: (Summer Mode Only)

1. The BMCS will monitor all the AHU's associated space humidity sensors to determine the critical space. The critical space is any space/zone with the highest reading above setpoint (initial setpoint – 50%, adj.).

    a. The humidity control mode shall override and take precedence over other modes of operation (i.e. unoccupied mode, supply air temperature reset, economizer & CO_2 control).

2. Once the critical space is determined (AHU-2), or the room humidity sensor is not within setpoint (AHU-1), the following will occur:

a. AHU-1: The chilled water control valve will open to 100% and the supply fan will modulate to maintain the room humidity setpoint.

1) If humidity is above setpoint and the supply fan is at minimum position and the space temp. drop below setpoint, the hot water control valve shall modulate in sequence to maintain room temp. setpoint.

b. AHU-2: The chilled water control valve will open to 100%.

3. When the respective space's humidity setpoint is satisfied, the AHU shall return to its previous operating mode.

H. Carbon Dioxide (CO_2) Control Mode:

1. The outdoor air CO_2 level shall be monitored and an initial 350 ppm delta (adj.) shall be added to establish the CO_2 setpoint.
2. The BMCS will monitor all the AHU's associated spaces and/or return air duct mounted CO_2 transmitters to determine the CO_2 level.

a. The BMCS shall identify, and display at the OWS, the CO_2 setpoint, and the CO_2 levels. This information shall update dynamically as the space setpoint and the location of the Critical Zone changes.

3. If CO_2 levels exceed setpoint, the following shall occur:

a. When the CO_2 levels are above setpoint, the OA damper shall be slowly positioned to increase the quantity of outside air to the AHU's occupied minimum setpoint (Refer to AHU schedule for airflow quantity).
b. As the CO_2 levels drop below setpoint, the OA damper shall be slowly positioned to decrease the quantity of outside air to the AHU's CO_2 minimum setpoint (Refer to AHU schedule for airflow quantity).

4. At any time, the quantity of outside air shall not be allowed to drop below the minimum CO_2 setpoint.

I. Return Air Damper Control: The Return Air Damper shall be software interlocked with the Outside Air Damper. The Return Air Damper shall be modulated to inversely track the Outdoor Air Damper position. The total airflow from both streams shall, as a minimum, equal the supply airflow required. RA & OA shall be monitored by the BMCS via the airflow monitoring stations.

J. The units are subject to system safeties:

1. A static pressure sensor shall monitor the supply duct static pressure. If the static pressure of the supply air duct exceeds the high pressure setpoint, the

BMCS shall command the unit to index to the unoccupied mode. The condition will require a manual reset.

a. An alarm will then be sent to the BMCS indicating that a shutdown of the system has occurred due to a "High Duct Static Pressure Condition".

2. A pressure differential switch shall be provided for all filter banks and will monitor their respective filter status. When the filters reach the pressure differential setpoint, an alarm will then be sent to the BMCS indicating that filter replacement is required.
3. The supply air ducts will be provided with smoke detectors. See floor plans for location(s). If products of combustion are sensed, the fans will be stopped and the outdoor, return and relief air dampers will close through a timed delay (adj.). The condition will require a manual reset.

   a. A local and remote, audible, and visual alarm shall be initiated indicating a "Smoke Condition".
   b. A signal shall be sent to the Central Fire Alarm System.

4. Current sensors installed at all fans shall monitor their status. If any motor fails to prove status for 30 seconds (adj.), that fan will be commanded off, the system shall be indexed to the unoccupied mode and an alarm shall be sent to the BMCS. A manual reset is required to restart the device.

POINT LIST:		Alarms to be set up by ATC:
AI	Supply Air Temperature, T1	Alarm on Failure
AI	Mixed Air Temperature, T2	Alarm on Failure
AI	Return Air Temperature, T3	Alarm on Failure
AI	Outside Air Temperature , T5	Alarm on Failure
AI	Airflow Measuring Station(s) (CFM)	Alarm on Failure
AI	Return Air Relative Humidity, H1	Alarm on Failure
AI	Supply Air Static Pressure, P1	Alarm on high static pressure
AI	Return Air CO2 sensor	Alarm on Failure or 50 PPM above setpoint.
DO	Supply Fan Start / Stop (S/S)	
AO	Supply Fan Speed	
DI	Supply Fan Status	Alarm on Fan Start Failure
DI	Supply Fan VFD Fault Status	Alarm on VFD Failure
DO	Return Fan S/S	

AO	Return Fan Speed	
DI	Return Fan Status	Alarm on Fan Start Failure
DI	Return Fan VFD Fault Status	Alarm on VFD Failure
DI	Filter Status(s) (all filter banks)	Alarm on high differential pressure
DI	Supply Duct Smoke Detector(s)	Advisory signal to CFAS on smoke
AO	Outdoor Air Damper, Modulate	Must be Separate from all dampers
AO	Return Air Damper, Modulate	Must be Separate from all dampers
AO	Exhaust Air Damper, Modulate	Must be Separate from all dampers

1.2 ROOFTOP UNITS (RTU-1 & 2)

A. General:

1. Unless specifically indicated otherwise, the following sequence of operations apply to all units.
2. The rooftop units (RTU's) shall be manually or automatically indexed between Morning Warm Up/Cool Down, Occupied/Unoccupied and Summer/Winter modes through the BMCS.
3. The systems will not be allowed to index into the occupied mode simultaneously. They shall have an offset interval of a min. of (2) two minutes (adj.) between each unit.
4. The systems will operate in sequence providing the system safeties are satisfied.
5. The RTU's shall operate as follows:

    a. Single Zone, Variable Volume, Variable Temperature.
    b. The BMCS contractor shall detail the operation of these strategies and provide any additional items (i.e. programming, software, hardware, devices, line & low voltage wiring, etc…), not included herein, in order to assure intended system operations.

6. During the commissioning process, the BMCS contractor shall demonstrate the performance of all sequences herein.
7. Space temperature sensors shall be provided a deadband of 5°F (adj.) within which the supply of heating and cooling energy to their respective spaces are shut-off or reduced to a minimum. The units supply fans shall be programmed to operate at the minimum airflow setting without addition of reheat when their respective space temperatures are within the set deadband.
8. All setpoints will be adjustable.
9. All data points will have ability to be trended.
10. All data points may be alarmed.

B. Unoccupied Mode:

1. Space Temperature Setpoints:

   a. Summer – 85 degrees F (adj.)
   b. Winter – 60 degrees F (adj.)

2. Space Humidity Setpoint: 50% (adj.)
3. The supply and return fans shall be off, the outdoor and exhaust air dampers will be closed, and the return air damper will be open, and the chilled and hot water control valves shall be closed. All system safeties shall remain operational.
4. The BMCS will monitor the space temperature and humidity sensors as follows:

   a. Winter mode: When any space temperature drops 2°F (adj.) below unoccupied setpoint.
   b. Summer Mode: When any space temperature rises 2°F (adj.) above unoccupied setpoint or when any space relative humidity rises 5% RH (adj.) above setpoint.

5. Temperature Control:

   a. Once the room temperature sensor is not within setpoint, the following will occur:

      1) The supply fan will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.
      2) The OA damper will remain closed, unless the economizer sequence is active.
      3) Warm Up: The packaged unit controls shall modulate/stage the gas-fired heating section to maintain the winter room temp. setpoint.
      4) Cool Down: The packaged unit controls shall command the economizer and/or DX refrigeration system, in sequence, to maintain the summer space temp. setpoint.

   b. Once their respective space(s) are satisfied, the unit components shall revert back to the condition indicated in paragraph B, 3 above.

6. Humidity Control:

   a. Once the room humidity sensor is not within setpoint, the following will occur:

      1) The supply fan will index to minimum position and the speed will increase as needed to maintain the room humidity setpoint. The reverse will occur as room humidity is satisfied.

2) The OA damper will remain closed, unless the economizer sequence is active.
3) The unit shall be indexed into the Humidity Control Mode.

b. Once their respective space is satisfied, the unit components shall revert back to the condition indicated in paragraph B, 3 above.

C. Morning Warm Up/Cool Down: (The mode will be initiated by the BMCS through an optimal start calculation.)

1. The supply and return fans shall be off, the outdoor and exhaust air dampers will be closed, the return air damper will be open, and the chilled and hot water control valves shall be closed.
2. The BMCS will monitor the space temperature and humidity sensors as follows:

a. Winter mode: When any space temperature drops 2°F (adj.) below unoccupied setpoint.
b. Summer Mode: When any space temperature rises 2°F (adj.) above unoccupied setpoint or when any space relative humidity rises 5% RH (adj.) above setpoint.

3. Once the room temperature sensor is not within setpoint, the following will occur:

a. The supply fan will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.
b. The speed of the return fan (RTU-1 only) will be modulated to track the unit's supply airflow. The return fan airflow shall be equal to the supply airflow minus the CFM differential between the supply and exhaust airflows indicated on the RTU schedule to maintain building pressurization. All airflows shall be verified via the airflow monitoring station and indicated at the BMCS.
c. The OA damper will remain closed, unless the economizer sequence is active.
d. Warm Up: The packaged unit controls shall modulate/stage the gas-fired heating section to maintain the winter room temp. setpoint.
e. Cool Down: The packaged unit controls shall command the economizer and/or DX refrigeration system, in sequence, to maintain the summer space temp. setpoint.
f. Once their respective space is satisfied, the unit will enter the occupied mode.

D. Occupied mode:

1. Space Temperature Setpoints:

a. Summer – 75 degrees F (adj.)

b. Winter – 70 degrees F (adj.)

2. Space Humidity Setpoint: 50% (adj.)
3. The outdoor air (OA) damper will open and position to the outside air minimum CO_2 setpoint (Refer to RTU schedule for airflow quantity). The outside air shall be verified via the airflow monitoring station and indicated at the BMCS.
4. The supply fans and return fan shall be enabled and run continuously. The fans shall run as follows:

   a. The supply fans will index to minimum position and the speed will increase as needed to maintain the room temperature setpoint. The reverse will occur as room temperature is satisfied.
   b. The speed of the return fan (RTU-1 only) will be modulated to track the unit's supply airflow. The return fan airflow shall be equal to the supply airflow minus the CFM differential between the supply and exhaust airflows indicated on the RTU schedule to maintain building pressurization. All airflows shall be verified via the airflow monitoring station and indicated at the BMCS.

5. Cooling Mode:

   a. The packaged unit controls shall command the economizer and/or DX refrigeration system, in sequence, to maintain the summer space temp. setpoint.

      1) Economizer Operation: When conditions are favorable (outside air enthalpy below return air enthalpy), the economizing sequence shall be active. The economizer shall be the primary stage of cooling.

6. Heating Mode:

   a. The packaged unit controls shall modulate/stage the gas-fired heating section to maintain the space temp. setpoint.

E. Economizer Mode:

1. Economizer control will be based on enthalpy comparison. If the outdoor air enthalpy is lower than the return air enthalpy, the BMCS shall command the RTU into the economizer mode.

   a. The economizer mode shall override and take precedence over other modes of operation (i.e. CO_2 control).

2. When the RTU's are in economizer mode, the units shall operate as follows:

   a. The outside air damper and mechanical cooling will be controlled to maintain the space temperature setpoint in the following manner:

1) Primary Stage: Mechanical cooling will be locked out and the OA damper will modulate between the CO_2 minimum setpoint position and 100% open (RTU supply airflow) to allow outdoor air to be delivered for free cooling.
2) Secondary Stage: If the outdoor air damper reaches 100% open and the space temperature setpoint cannot be maintained using outdoor air alone, the outdoor air damper will be held 100% open and mechanical cooling will be enabled.

3. When the outdoor enthalpy rises above the return air enthalpy, the AHU shall return to its previous operating mode.

F. Humidity Control Mode: (Summer Mode Only)

1. The BMCS will monitor all the RTU's associated space or return air duct mounted humidity sensors to determine if the setpoint is above setpoint (initial setpoint – 50%, adj.).

   a. The humidity control mode shall override and take precedence over other modes of operation (i.e. unoccupied mode, economizer & CO_2 control).

2. Once the room humidity sensor is not within setpoint, the packaged unit controls shall command the DX refrigeration system to maximum output to maintain the summer space humidity setpoint.

   a. If humidity is above setpoint and the supply fan is at minimum position and the space temp. drops below setpoint, the packaged unit controls shall modulate/stage the gas-fired heating section, or if provided, hot-gas reheat, to maintain the space temp. setpoint.

3. When their respective space's humidity setpoint is satisfied, the RTU shall return to its previous operating mode.

G. Carbon Dioxide (CO_2) Control Mode:

1. The outdoor air CO_2 level shall be monitored and an initial 350 ppm delta (adj.) shall be added to establish the CO_2 setpoint.
2. The BMCS will monitor the RTU's associated space or return air duct mounted CO_2 transmitters to determine the CO_2 level.

   a. The BMCS shall identify, and display at the OWS, the CO_2 setpoint, and the CO_2 levels. This information shall update dynamically as the space setpoint and the location of the Critical Zone changes.

3. If CO_2 levels exceed setpoint, the following shall occur:

a. When the CO_2 levels are above setpoint, the OA damper shall be slowly positioned to increase the quantity of outside air to the RTU's occupied minimum setpoint (Refer to RTU schedule for airflow quantity).
b. As the CO_2 levels drop below setpoint, the OA damper shall be slowly positioned to decrease the quantity of outside air to the RTU's CO_2 minimum setpoint (Refer to RTU schedule for airflow quantity).

4. At any time, the quantity of outside air shall not be allowed to drop below the minimum CO_2 setpoint.

H. Return Air Damper Control (RTU-1 Only): The Return Air Damper shall be software interlocked with the Outside Air Damper. The Return Air Damper shall be modulated to inversely track the Outdoor Air Damper position. The total airflow from both streams shall, as a minimum, equal the supply airflow required. RA & OA shall be monitored by the BMCS via the airflow monitoring stations.

I. The units are subject to system safeties:

1. A static pressure sensor shall monitor the supply duct static pressure. If the static pressure of the supply air duct exceeds the high pressure setpoint, the BMCS shall command the unit to index to the unoccupied mode. The condition will require a manual reset.

a. An alarm will then be sent to the BMCS indicating that a shutdown of the system has occurred due to a "High Duct Static Pressure Condition".

2. A pressure differential switch shall be provided for all filter banks and will monitor their respective filter status. When the filters reach the pressure differential setpoint, an alarm will then be sent to the BMCS indicating that filter replacement is required.
3. The supply air ducts will be provided with smoke detectors. See floor plans for location(s). If products of combustion are sensed, the fans will be stopped and the outdoor, return and relief air dampers will close through a timed delay (adj.). The condition will require a manual reset.

a. A local and remote, audible, and visual alarm shall be initiated indicating a "Smoke Condition".
b. A signal shall be sent to the Central Fire Alarm System.

4. Current sensors installed at all fans shall monitor their status. If any motor fails to prove status for 30 seconds (adj.), that fan will be commanded off, the system shall be indexed to the unoccupied mode and an alarm shall be sent to the BMCS. A manual reset is required to restart the device.

POINT LIST:		Alarms to be set up by ATC:
AI	Supply Air Temperature, T1	Alarm on Failure

AI	Mixed Air Temperature, T2	Alarm on Failure
AI	Return Air Temperature, T3	Alarm on Failure
AI	Outside Air Temperature , T5	Alarm on Failure
AI	Airflow Measuring Station(s) (CFM)	Alarm on Failure
AI	Return Air Relative Humidity, H1	Alarm on Failure
AI	Supply Air Static Pressure, P1	Alarm on high static pressure
AI	Return Air CO2 sensor	Alarm on Failure or 50 PPM above setpoint.
DO	Supply Fan Start / Stop (S/S)	
AO	Supply Fan Speed	
DI	Supply Fan Status	Alarm on Fan Start Failure
DI	Supply Fan VFD Fault Status	Alarm on VFD Failure
DO	Return Fan S/S	
AO	Return Fan Speed	
DI	Return Fan Status	Alarm on Fan Start Failure
DI	Return Fan VFD Fault Status	Alarm on VFD Failure
DI	Filter Status(s) (all filter banks)	Alarm on high differential pressure
DI	Supply Duct Smoke Detector(s)	Advisory signal to CFAS on smoke
AO	Outdoor Air Damper, Modulate	Must be Separate from all dampers
AO	Return Air Damper, Modulate	Must be Separate from all dampers
AO	Exhaust Air Damper, Modulate	Must be Separate from all dampers

1.3 TERMINAL UNITS (VAV) W/ REHEAT AND CEILING RADIANT PANELS OR BASEBOARD FINTUBE RADIATION (PRESSURE INDEPENDENT CONTROL)

A. General:

1. Modes of operation are determined by the BMCS for the respective AHU serving the terminal box.
2. A room lighting occupancy sensor, by Division 26, shall index the terminal box from occupied mode to a standby mode while the AHU is in the occupied mode when the sensor does not detect adequate movement. Coordinate interface requirements with the work by Division 26.

3. Where a single space utilizes multiple terminal units (i.e. Cafeteria, Gymnasium, Media Center, etc…), each terminal unit shall be controlled in the same manner as defined below, simultaneously, by the space's thermostat.

B. Variable Volume Operation: (Where terminal units have different minimum and maximum airflow settings)

1. Occupied mode: The terminal units are controlled within user defined maximum and minimum supply air volume settings, refer to floor plans and schedule.

a. Winter Mode Operation: The terminal units shall be initially set to their minimum position, their respective reheat coil control valves shall be closed and their respective radiation control valves shall be open. Each terminal unit shall be controlled as follows:

1) The TEC shall monitor the room temperature and air velocity sensors and modulate the primary supply air damper in sequence with the radiation control valves and the reheat coil to maintain the room temperature at setpoint (adj.).

a) As room temperature drops below setpoint, the radiation control valve shall modulate first in the sequence. When it is open to 100% and room temperature is still below setpoint, the reheat coil control valve(s) shall then be modulated to maintain room temperature setpoint.
b) As room temperature rises above setpoint, the reheat coil control valve(s) shall be closed, and the radiation control valve shall be modulated to maintain setpoint. On a further rise in room temperature, radiation control valve shall be closed and the TEC shall modulate the primary supply air damper(s) open.

b. Summer Mode Operation: The terminal units shall be initially set to their maximum position, and their respective reheat coil and radiation control valves shall be closed. Each terminal unit shall be controlled as follows:

1) The TEC shall monitor the room temperature and air velocity sensors and modulate the primary supply air damper in sequence with the reheat coil to maintain the room temperature at setpoint (adj.).

a) As room temperature drops below setpoint, the TEC shall modulate the primary supply air damper(s) closed to its minimum position. On a further drop in room temperature, the TEC shall modulate the reheat coil control valve(s).
b) As room temperature rises above setpoint, the TEC shall modulate the primary supply air damper(s) open to its maximum position.

C. Constant Volume Operation: (Where terminal units have identical minimum and maximum airflow settings)

1. Occupied mode: The terminal units are controlled to maintain a constant supply air volume, refer to floor plans and schedule.

a. Winter Mode Operation: The terminal unit's respective reheat coil control valve(s) and radiation control valve(s) shall be controlled as follows:

1) As room temperature drops below setpoint, the radiation control valve shall modulate first in the sequence. When it is open to 100% and room temperature is still below setpoint, the reheat coil control valve shall then be modulated to maintain room temperature setpoint.
2) As room temperature rises above setpoint, the reheat coil control valve shall be closed, and the radiation control valve shall be modulated to maintain setpoint. On a further rise in room temperature, radiation control valve shall be closed.

b. Summer Mode Operation: The terminal unit's respective radiation control valve(s) shall be closed. The terminal unit's respective reheat coil control valve(s) shall be controlled as follows:

1) The reheat coil control valve will be modulated to maintain room temperature setpoint.

D. Unoccupied Mode:

1. When commanded to change over to the unoccupied mode of operation by the BMCS, the TEC shall operate the terminal units as described above and raise the cooling setpoint (85˚F setup – adj.) and decrease the heating setpoint (60˚F setback – adj.).
2. The TEC shall be reset to occupied mode cooling and heating temp. setpoints for an operator-determined period. This reset shall be activated by a signal from a local override switch on the room temperature sensor or by command from the operator's work station. At the end of the operator-determined period, the TEC shall return to the unoccupied mode.

POINT LIST:		Alarms to be set up by ATC:
AI	Space Temperature	Alarm on failure or + / - 4 degrees of setpoint
AI	Space Temperature Setpoint	
AI	Discharge Air Temperature	
AI	Airflow CFM	
AO	Damper Control	

AO Hot Water Reheat Valve Modulate (NOT ON / OFF)

AO Hot Water Radiation Valve Modulate (NOT ON / OFF)

DI Hot Water Radiation Valve Position (100% Open)

1.4 KITCHEN MAKEUP AND EXHAUST SYSTEM, MUA-1 & KHE-1

A. General:

1. The makeup air (MUA) unit and exhaust fan (EF), “the system”, shall be controlled via the MUA unit's packaged controls. A remote-control panel provided by the MUA unit manufacturer will be field installed by the mechanical contractor. The mechanical contractor shall coordinate with the Owner’s representative to determine the final mounting location within the kitchen.

    a. The BMCS contractor shall coordinate with the mechanical and kitchen contractors to provide all necessary components to interface the system for monitoring of fan & filter status, SA & OA temperatures, alarms and for remote system enable/disable via the BMCS.
    b. The BMCS contractor shall also coordinate and provide all necessary control components to achieve the sequence of operations, described herein, which are not part of the MUA unit's packaged controls.

2. The system will operate in sequence providing the system safeties are satisfied.
3. The system shall operate as variable volume, constant temperature system.

B. The system operation shall be interlocked with the operation of the RTU-2 via the BMCS and shall be sequenced as follows.

1. Un-occupied mode: The system shall be disabled.
2. Occupied mode: The system shall be enabled.
3. The system operation shall also be capable of being manually overridden and enabled, through the system's remote control panel. The BMCS shall override the operating mode of RTU-2 in response and index it into occupied mode.

    a. When enabled, the system shall operate as indicated below and RTU-2 shall operate in accordance with its sequence of operation.
    b. The system and RTU shall operate for a timed period (adj.) and then revert to the operating mode prior to the override.

C. When the system is enabled:

1. The MUA intake damper will open, and through the damper end switch, the MUA & KHE fans shall start and run continuously. The fans will be monitored for run status.

2. The duct mounted temperature sensor will modulate the respective DX cooling or gas-fired heating systems, via the MUA's packaged controls, to maintain the supply air discharge temperature setpoint.

    a. Winter Setpoint: 70°F (adjustable).
    b. Summer Setpoint: 75°F (adjustable).

D. When the system is disabled:

1. The system fans shall stop and the intake damper will close through a timed delay (30 sec. - adj.).

E. The units are subject to system safeties:

1. A pressure differential switch shall be provided for all filter banks and will monitor their respective filter status.

    a. When the filters reach the pressure differential setpoint, an alarm will then be sent to the BMCS indicating that filter replacement/cleaning is required.

2. The supply air duct will be provided with a smoke detector. If products of combustion are sensed, the fans will be stopped and the intake air damper will close. The condition will require a manual reset.

    a. A local and remote, audible and visual alarm shall be initiated indicating a “Smoke Condition”.
    b. A signal shall be sent to the Central Fire Alarm System.

3. A current switch for each fan will monitor the fan’s run status.

    a. If any of the fans fail to start, an alarm will be generated at the BMCS and indicate the system that differs from its command.

POINT LIST:		Alarms to be set up by ATC
DO	system start / stop	
DI	Fan Status, supply and exhaust	Alarm on failure
DI	Filter Status	Alarm on high differential pressure
AI	Supply Air Temperature	Alarm on Failure
AI	Outside Air Temperature	Alarm on Failure

1.5 SPLIT, AIR-CONDITIONING SYSTEMS (AC & ACCU)

A. General:

1. The air-conditioning systems shall be manually or automatically indexed between Summer/Winter modes through the OWS.
2. The systems will operate in sequence providing the system safeties are satisfied.
3. The AC & CRAC unit is constant volume, variable temperature.
4. All setpoints will be adjustable.
5. All data points will have ability to be trended.
6. All data points may be alarmed.
7. The units do not have economizer capabilities.

B. The AC units' packaged controls shall sequence its internal and external system components to maintain the room temperature setpoint (initial setpoint: 75° F Summer and 70° F Winter – adj.).

C. Control wiring for the interconnection between the indoor evaporator unit and its respective outdoor condensing unit, drycooler and pump package will be by the BMCS contractor. Coordinate in accordance with the unit manufacturer's installation instructions.

D. The unit shall be stopped through a software interlock from the central fire alarm system, upon detection of smoke or a fire.

E. Provide an interface to the BMCS. Coordinate with additional requirements indicated in Section 23 81 23 & 23 81 24. As a minimum, provide for the following features:

1. Start/stop
2. Unit status
3. Alarm monitoring

F. A water detector placed on the floor next to the unit will be monitored by the BMCS and alarmed. See "LIQUID DETECTION" below for additional info.

POINT LIST:		Alarms to be set up by ATC
DO	System start / stop	
DI	Unit Status	Alarm on failure
DI	Alarm Status	

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 00 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 00 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 00 and 23 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Ppe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Medium Temperature Hot-water heating piping.
3. Chilled-water piping.
4. Condenser-water piping.
5. Makeup-water piping.
6. Condensate-drain piping.
7. Air-vent piping.
8. Safety-valve-inlet and -outlet piping.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

C. Section 23 05 23 - General-duty Valves for HVAC Piping

D. Section 23 21 23 - Hydronic Pumps: Pumps, motors, and accessories for hydronic piping.

1.4 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: 150 psig at 250 degree F.
2. Medium Temperature Hot-water heating piping: 250 psig at 400 degree F.
3. Chilled-Water Piping: 150 psig at 150 degree F.
4. Condenser-Water Piping: 150 psig at 150 degree F.
5. Makeup-Water Piping: 80 psig at 150 degree F.

6. Condensate-Drain Piping: 150 degree F.
7. Air-Vent Piping: 200 degree F.
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.5 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: For each type of the following:

1. Pressure-seal fittings.
2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
3. Air control devices.
4. Chemical treatment.
5. Hydronic specialties.

C. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

D. Welding certificates.

E. Qualification Data: For Installer.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.7 EXTRA MATERIALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B88, Type K.

C. DWV Copper Tubing: ASTM B306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Anvil International, Inc.
b. S. P. Fittings; a division of Star Pipe Products.

E. Copper or Bronze Pressure-Seal Fittings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Stadler-Viega.

2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.

5. Minimum 200-psig working-pressure rating at 250 degree F.

F. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" article.

F. Wrought-Steel Fittings: ASTM A234, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Hart Industries International, Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 degree F.

D. Dielectric Flanges:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.
b. Central Plastics Company.

c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Calpico, Inc.
b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and non-corrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degree F.

G. Dielectric Nipples:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Perfection Corporation; a subsidiary of American Meter Company.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Company, Inc.

2. Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degree F.

2.5 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23.

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00.

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Bell & Gossett Domestic Pump; a division of ITT Industries.
b. Flow Design Inc.
c. Gerand Engineering Co.
d. Griswold Controls.
e. Taco.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 degree F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Bell & Gossett Domestic Pump; a division of ITT Industries.
b. Flow Design Inc.
c. Gerand Engineering Co.
d. Griswold Controls.
e. Taco.
f. Tour & Andersson; available through Victaulic Company of America.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 degree F.

E. Diaphragm-Operated, Pressure-Reducing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Amtrol, Inc.
    b. Bell & Gossett Domestic Pump; a division of ITT Industries.
    c. Conbraco Industries, Inc.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Non-corrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Amtrol, Inc.
    b. Bell & Gossett Domestic Pump; a division of ITT Industries.
    c. Conbraco Industries, Inc.
    d. Spence Engineering Company, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.

3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Non-corrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.6 AIR CONTROL DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Amtrol, Inc.
2. Bell & Gossett Domestic Pump; a division of ITT Industries.
3. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 degree F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Non-corrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 degree F.

D. Diaphragm-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 degree F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 degree F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

F. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 degree F.

G. Air Purgers:

1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
2. Maximum Working Pressure: 150 psig.
3. Maximum Operating Temperature: 250 degree F.

2.7 CHEMICAL TREATMENT

A. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

B. Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

2.8 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

D. Stainless Steel Bellow, Flexible Connectors:

1. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 degree F.

E. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 degree F.

F. Expansion fittings are specified in Section 23 05 16.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller**,** shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed, or pressure-seal joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Hot-water heating piping installed belowground and within slabs, unless otherwise indicated, shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

D. Chilled-water piping, aboveground, NPS 2 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed or pressure-seal joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

F. Chilled-water piping installed belowground and within slabs, unless otherwise indicated, shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

G. Dual-temperature heating and cooling water piping, aboveground, NPS 2 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed or pressure-seal joints.

H. Dual-temperature heating and cooling water piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

I. Dual-temperature heating and cooling water piping installed belowground and within slabs, unless otherwise indicated, shall be the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

J. Condenser-water piping, aboveground, NPS 2 and smaller, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed or pressure-seal joints.

K. Condenser-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

L. Makeup-water piping installed aboveground shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.

M. Makeup-Water Piping Installed Belowground and within Slabs:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

N. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

O. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

P. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

Q. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 23 05 23.

Q. Install unions in piping**,** NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install flexible pipe connectors at connections for all equipment supported on vibration isolators.

T. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 23 05 16 and as otherwise indicated on the contract drawings.

V. Identify piping as specified in Section 23 05 53.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 23 05 29. Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Section 23 05 48.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4-inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4-inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8-inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8-inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8-inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2-inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2-inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8-inch.
10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4-inch.
11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8-inch.
12. NPS 14: Maximum span, 25 feet; minimum rod size, 1-inch.
13. NPS 16: Maximum span, 27 feet; minimum rod size, 1-inch.
14. NPS 18: Maximum span, 28 feet; minimum rod size, 1-1/4 inches.
15. NPS 20: Maximum span, 30 feet; minimum rod size, 1-1/4 inches.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4-inch.

2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4-inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

H. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846 Appendix.
3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.
4. PVC Non-pressure Piping: Join according to ASTM D2855.

J. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

K. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

L. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

M. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install air vents at all high points of system piping and at heat-transfer coils and elsewhere as required for air venting. Provide automatic vents in mechanical equipment rooms only, manual elsewhere.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a two (2) percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to

nearest equipment drain and include a full-size, full-port, ball valve. Refer to Section 23 25 00 for additional information.

E. Where indicated on plans, Install horizontal expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Where indicated, Install vertical expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system project requirements. Refer to tank manufacturer's written instructions and recommendations for tank charging information.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment. Where control valves are in inaccessible locations, coordinate with the work by other Divisions for access doors in the finished surfaces.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Section 23 05 19.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Anticipated working pressure is approximately 30 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 30 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.9 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 05 00 - Common Work Results for HVAC.

C. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

D. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

E. Section 23 07 00 - HVAC Insulation.

F. Section 23 08 00 - Commissioning of HVAC.

G. Section 23 21 13 - Hydronic Piping.

H. Section 26 29 13 - Enclosed Controllers: Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

I. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1. Variable-frequency motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

1.3 SECTION INCLUDES

A. Close-coupled, in-line centrifugal pumps.

B. Vertical split-case, centrifugal pumps

C. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.4 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

C. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Power, signal, and control wiring.

D. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Section 01 25 00.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 DELIVERY, STORAGE AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One (1) mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers:

1. Provide the product indicated on drawings, no other manufacturers will be considered.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125-psig minimum working pressure and a continuous water temperature of 200 degrees F.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings or Oil lubricated; bronze-journal or thrust type.

D. Single speed or inverter duty rated, depending on service requirement. Verify each requirement with the Pump Schedule in Mechanical contract drawings. Motors to have permanently lubricated or grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Section 23 05 13.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

B. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Section 23 05 48. Fabricate brackets or supports as required. Hanger and support materials are specified in Section 23 05 29.

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Section 21 05 48. Hanger and support materials are specified in Sections 22 05 29 and 23 05 29.

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

G. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.3 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Install electrical connections for power, controls, and devices.

K. Ground equipment according to Section 26 05 26.

L. Connect wiring according to Section 26 05 19.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.

3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 8 hours to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Pipe and fittings for LP and HP steam and condensate piping:

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

C. Section 23 22 16 - Steam and Condensate Piping Specialties: Strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.4 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.5 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

C. Qualification Data: For installer.

D. Welding certificates.

E. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: More than 15 psig.
2. LP Steam Piping: 15 psig or less.

3. Condensate Piping: 15 psig at 250 degrees F.
4. Makeup-Water Piping: 80 psig at 150 degrees F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A234, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A733, made of ASTM A53, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. LP Steam Piping, NPS 14 through NPS 18: Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. LP Steam Piping, NPS 20 and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

G. Condensate piping below grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

H. Condensate piping below grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Section 23 05 23

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

U. Comply with requirements in Section 23 05 16 for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 23 05 53 for identifying piping.

W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17.

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17.

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18.

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 23 22 16 for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 for installation of hangers and supports. Comply with requirements below for maximum spacing.

B. Comply with requirements in Section 23 05 48 for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping with the following maximum spacing:

1. NPS 3/4: Maximum span, nine (9) feet.
2. NPS 1: Maximum span, nine (9) feet.
3. NPS 1-1/2: Maximum span, 12 feet.
4. NPS 2: Maximum span, 13 feet.
5. NPS 2-1/2: Maximum span, 14 feet.
6. NPS 3 and Larger: Maximum span, 15 feet.

E. Install hangers for steel steam condensate piping with the following maximum spacing:

1. NPS 3/4: Maximum span, seven (7) feet.
2. NPS 1: Maximum span, seven (7) feet.
3. NPS 1-1/2: Maximum span, nine (9) feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M, using qualified processes and welding operators according to "Quality Assurance" article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one (1) bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1-2012, "Power Piping," and ASME B31.9-2011, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Working pressure shall be equal to that of the existing steam distribution system and shall be verified by the MC in the field. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 30 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare test and inspection reports.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Piping specialties for LP and HP steam and condensate piping including the following:

1. Strainers.
2. Flash tanks.
3. Safety valves.
4. Pressure-reducing valves.
5. Steam traps.
6. Thermostatic air vents and vacuum breakers.
7. Steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of the following:

1. Pressure-reducing and safety valve.
2. Steam trap.
3. Air vent and vacuum breaker.
4. Flash tank.
5. Meter.

1.4 CLOSEOUT SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: more than15 psig.
2. LP Steam Piping: 15 psig or less.

3. Condensate Piping: 15 psig at 250 degrees F.
4. Makeup-Water Piping: 80 psig at 150 degrees F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23.

B. Stop-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. A.Y. McDonald Mfg. Co.
b. Cincinnati Valve Company.
c. Crane; Crane Energy Flow Solutions.
d. Jenkins Valves.
e. Lunkenheimer Valves.

2. Body and Bonnet: Malleable iron.

3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

B. Basket Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 20-mesh strainer, and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

2.4 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.5 SAFETY VALVES

A. Bronze or Brass Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armstrong International, Inc.
b. Kunkle Valve.
c. Spirax Sarco, Inc.
d. Watts; a Watts Water Technologies company.

2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Safety Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armstrong International, Inc.
b. Kunkle Valve.
c. Spirax Sarco, Inc.
d. Watts; a Watts Water Technologies company.

2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.6 PRESSURE-REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Armstrong International, Inc.
2. Hoffman Specialty.
3. Leslie Controls, Inc.

4. Spence Engineering Company, Inc.
5. Spirax Sarco, Inc.

B. ASME labeled.

C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.

E. Body: Cast iron.

F. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

G. Trim: Hardened stainless steel.

H. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

I. Gaskets: Non-asbestos materials.

J. Capacities and Characteristics: As indicated on the drawings.

2.7 STEAM TRAPS

A. Thermostatic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Armstrong International, Inc.
   b. Hoffman Specialty.
   c. Spirax Sarco, Inc.

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced-pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermodynamic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armstrong International, Inc.
b. Hoffman Specialty.
c. Spirax Sarco, Inc.

2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig.

C. Float and Thermostatic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armstrong International, Inc.
b. Hoffman Specialty.
c. Spirax Sarco, Inc.

2. Body and Bolted Cap: ASTM A126, cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 degrees F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

D. Inverted Bucket Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armstrong International, Inc.
b. Hoffman Specialty.
c. Spirax Sarco, Inc.

2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless-steel inlet strainer within the trap body.
8. Air Vent: Stainless steel thermostatic vent.
9. Pressure Rating: 250 psig.

2.8 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Armstrong International, Inc.
    b. Hoffman Specialty.
    c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 degrees F.

B. Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Armstrong International, Inc.
    b. Hoffman Specialty.
    c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-Ring Seal: EPR.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 degrees F.

2.9 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Duraflex, Inc.
    b. Flexicraft Industries.
    c. Hyspan Precision Products, Inc.
    d. Mason Industries, Inc.
    e. Metraflex Company (The).

2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 degrees F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 23 05 23.

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Flash Tank:

1. Pitch condensate piping down toward flash tank.
2. If more than one (1) condensate pipe discharges into flash tank, install a check valve in each line.
3. Install thermostatic air vent at tank top.
4. Install safety valve at tank top.
5. Install full-port ball valve, and swing check valve on condensate outlet.
6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three (3) times the calculated heat load.

7. Install pressure gage on low-pressure steam outlet according to Section 23 05 19.

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves (PRV), with globe valve equal in size to area of pressure-reducing valve seat ring of the largest PRV, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

E. Install pressure gages on high-pressure side and low-pressure side of pressure-reducing valves after the bypass connection according to Section 23 05 19.

F. Install moisture separators upstream of the strainers.

G. Install strainers upstream for pressure-reducing valve.

H. Install safety valve downstream from pressure-reducing valve station.

3.5 STEAM OR CONDENSATE METER INSTALLATION

A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's written instructions.

B. Provide data acquisition wiring. See Section 23 09 23.

3.6 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.1, "Power Piping"; and ASME B31.9, "Building Services Piping".

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one (1) bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Refrigerant piping used for air-conditioning applications.

1.3 RELATED SECTIONS

A. Section 01 91 13 - General Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

1.4 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-22:

1. Suction Lines for Air-Conditioning Applications: 185 psig.
2. Suction Lines for Heat-Pump Applications: 325 psig.
3. Hot-Gas and Liquid Lines: 325 psig.

B. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig.
2. Suction Lines for Heat-Pump Applications: 225 psig.
3. Hot-Gas and Liquid Lines: 225 psig.

C. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig.
2. Suction Lines for Heat-Pump Applications: 380 psig.
3. Hot-Gas and Liquid Lines: 380 psig.

D. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

C. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

D. Welding certificates.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15-2016, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5-2013, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B88, Type K or L or ASTM B280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 degrees F.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A234, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four (4) plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
6. Pressure Rating: Factory test at minimum 400 psig.
7. Maximum Operating Temperature: 330 degrees F.

F. Flexible Connectors:

1. Body: Stainless steel bellows with woven, flexible, stainless steel wire-reinforced protective jacket.
2. End Connections:

   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 degrees F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 degrees F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Non-rotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.

6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 degrees F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 degrees F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 degrees F.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 degrees F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 degrees F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 115-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 degrees F.

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 degrees F.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 degrees F.

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.

3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 degrees F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: Two (2) psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 degrees F.

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: Two (2) psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 degrees F.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 degrees F.

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.

5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 degrees F.

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 degrees F.

2.4 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-22: Monochlorodifluoromethane.

D. ASHRAE 34, R-134a: Tetrafluoroethane.

E. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

F. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-22

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 4: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 4: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
2. NPS 1-1/4 to NPS 2: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
3. NPS 4: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
1. NPS 1-1/4 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
2. NPS 1-1/2 to NPS 2: Copper, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
3. NPS 4: Schedule 40, black-steel and wrought-steel fittings with welded joints.

D. Safety-Relief-Valve Discharge Piping:
1. NPS 1-1/4 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
2. NPS 1-1/2 to NPS 2: Copper, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints
3. NPS 4: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.5 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line. Verify proper location for bulb with valve manufacturer
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

K. Install receivers sized to accommodate pump-down charge. Consult refrigeration equipment manufacturer to determine the need for a receiver

L. Install flexible connectors at compressors.

3.6 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on shop drawings.

B. Install refrigerant piping according to ASHRAE 15-2016.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Sections 23 09 00 and 23 09 93 for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 00 if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

S. Seal penetrations through fire and smoke barriers according to Section 07 84 13.

T. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

U. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

V. Seal pipe penetrations through exterior walls according to Section 07 92 00 for materials and methods.

W. Identify refrigerant piping and valves according to Section 23 05 53.

3.7 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 23 05 29.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4-inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4-inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4-inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8-inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8-inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8-inch.

7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8-inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2-inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8-inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8-inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8-inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2-inch.

E. Support multifloor vertical runs at least at each floor.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test. Test duration shall be a min. of 30 minutes.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

3.12 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 13 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 13 and manufacturer’s written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 13 and 23 08 00 and manufacturer’s written instructions/requirements.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Single-wall rectangular ducts and fittings.

B. Single-wall round and flat-oval ducts and fittings.

C. Double-wall round ducts and fittings.

D. Sheet metal materials.

E. Duct liner.

F. Sealants and gaskets.

G. Hangers and supports.

H. Seismic-restraint devices.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 07 84 13 - Penetration Firestopping.

C. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC: Testing, adjusting, and balancing requirements for metal ducts.

D. Section 23 07 00 - HVAC Insulation.

E. Section 23 08 00 - Commissioning of HVAC.

F. Section 23 33 00 - Air Duct Accessories: Dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" article, whichever is more stringent.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

E. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

F. Welding certificates.

G. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes in excess of 3-inch wg. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

   a. Five (5) transverse joints.
   b. One (1) access door(s).
   c. Two (2) typical branch connections, each with at least one (1) elbow.
   d. Two (2) typical flexible duct or flexible-connector connections for each duct and apparatus.
   e. One (1) 90-degree turn(s) with turning vanes.
   f. One (1) fire damper(s).
   g. Perform leakage tests specified in "Field Quality Control" article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on external static-pressure of the respective system, indicated on the air handling unit schedule.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on external static-pressure of the respective system, indicated on the air handling unit schedule.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Inner & Outer Duct: Ducts shall be of spiral lock seam construction with a mechanically formed seam locking indentation evenly spaced along the spiral seam and comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on external static-pressure of the respective system, indicated on the air handling unit schedule.

1. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch to 1/8-inch diameter perforations, with an overall open area of 23 percent.
2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

4. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Interstitial Insulation: 1" thick x 1.0 lb/ft3 layer of Fibrous-glass liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in/h x sq ft x degrees F at 75 degrees F mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Cover insulation with polyester film complying with UL 181, Class 1.

E. Joint Sealing: Fitting ends shall be equipped with factory installed gaskets. The system tightness shall be factory warranted to meet SMACNA's Leakage Class 3 performance.

F. Gaskets: The gasket shall be EPDM rubber. The gasket shall be located in a groove at the end of the fitting and securely fastened by means of a stainless steel band. In order to achieve optimum sealing for all diameters, different size gaskets shall be used. The gasket shall be classified by Underwriters Laboratories for flame spread and smoke developed in accordance with ASTM E84.

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653.

1. Galvanized Coating Designation: G90.
2. Minimum Thickness for Factory-Applied PVC Coating: Four (4) mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum one (1) mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A1008, with oiled, matte finish for exposed ducts.

E. Stainless Steel Sheets: Comply with ASTM A480, Type 304 or 316, as indicated in the "Duct Schedule" article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" article.

F. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Reinforcement Shapes and Plates: ASTM A36, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Duct lining indicated on the drawings and as specified herein is for sound absorption only, however, where internal duct lining meets the thermal performance characteristics of external insulation, external insulation shall not be required where the duct system is internally lined. Refer to Section 23 07 00 for additional information.

B. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. CertainTeed Corporation; Insulation Group.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.
e. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in/h x sq ft x degrees F at 75 degrees F mean temperature.
2) Type II, Rigid: 0.23 Btu x in/h x sq ft x degrees F at 75 degrees F mean temperature.

2. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners four (4) inches from corners and at intervals not exceeding 12 inches transversely; at three (3) inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: Four (4) inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 degrees F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq ft at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Non-corrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:

1. Supports for Galvanized Steel Ducts: Galvanized steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.

3. Kinetics Noise Control.
4. Loos & Co.; Cableware Division.
5. Mason Industries.
6. TOLCO; a brand of NIBCO INC.
7. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A603 galvanized steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on shop drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible - 2005" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of one (1) inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class B.
4. Outdoor, Return-Air Ducts: Seal Class B.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class B.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class B.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, or structural steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Do not use powder-actuated concrete fasteners for any purposes.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized steel primer. Paint materials and application requirements are specified in Division 09 painting sections.

B. In finished, occupied areas with exposed ductwork (i.e. Gymnasiums, Cafeterias, Galleries, etc…) coordinate painting of all exposed duct surfaces, including all duct hangers, supports, restraints, etc… Paint materials and application requirements are specified in Division 09 painting sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

6. Give seven (7) days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.

3.9 START UP

A. Air Balance: Comply with requirements in Section 23 05 93.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, PVC coated, galvanized sheet steel.
2. Ducts conveying outdoor-air or moisture-ladened air (i.e. locker rooms with showers, etc…): Aluminum.
3. Ducts Connected to Type 1 Commercial Kitchen Hoods: See below.
4. Ducts Connected to Laboratory Fume Hoods: See below.

B. Supply, Return, Outdoor-Air or Exhaust Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. SMACNA Leakage Class: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative. Unless otherwise indicated, construct ducts to a pressure class that exceeds the scheduled external pressure rating of the fan, but no less than 3-inch wg.
b. SMACNA Leakage Class: 3.

3. Ducts Connected to Type 1 Commercial Kitchen Hoods:

a. Construct kitchen hood grease ducts and supports of No. 16 MSG carbon steel or No. 18 MSG 304 stainless steel with continuously welded liquid-tight joints and seams.

1) Install grease ducts to avoid forming dips or traps where residue may collect. Pitch ductwork downward not less than 1/4 unit in 12 units (2-percent slope) towards the kitchen hood or grease reservoir. Where horizontal ducts exceed 75 feet in length, the slope shall not be less than 1 unit in 12 units (8.3-percent slope).
2) Install access openings at each change in direction and at intervals most stringently defined by the Mechanical Code, and as indicated below; locate on sides of duct a minimum of 1-1/2 inches from bottom; and fit with grease-tight covers of same material and thickness as duct. Covers shall be operable without the use of a tool and fasteners shall not penetrate the duct.

a) Horizontal Duct Access Openings: Locate access openings large enough for thorough cleaning in horizontal sections every 20 linear feet, at the base of risers, at all changes in direction and as otherwise indicated.

b) Where ducts are to have fire rated duct wrap insulation applied, access opening cover shall be provided in accordance with the fire rated duct wrap insulation manufacturer's installation details. Access opening flanged extension for cover mounts shall not be used.
c) Where ducts are to be located in a fire-resistance-rated enclosure, provide access openings at each cleanout point in the ductwork.

3) Insulate with adequate material to maintain clearances to combustible and non-combustible materials. Comply with requirements of the IMC.
4) Provide ductwork continuously covered on all sides with a fire rated duct wrap insulation system, similar to 3M Fire Barrier Duct Wrap 615+, from the point at which the ductwork penetrates a floor, wall or ceiling, to a rated enclosure or shaft. Provide firestopping through all rated construction in accordance with Division 07 and with ASTM E814 and having an "F" and "T" rating equal to the fire-resistance rating of the assembly being penetrated.

b. Pressure Class: Negative. Unless otherwise indicated, construct ducts to a pressure class that exceeds the scheduled total static pressure rating of the fan, but no less than 2-inch wg.
c. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
d. SMACNA Leakage Class: 3.

4. Ducts Connected to Laboratory Fume Hoods:

a. Laboratory Exhaust (Fume-Handling) Ducts: Type 316, stainless steel sheet with No. 4 finish for exposed in finished indoor applications, No. 2D finish for all other applications. Duct thickness (minimum 20 gage).
b. Pressure Class: Negative. Unless otherwise indicated, construct ducts to a pressure class that exceeds the scheduled total static pressure rating of the fan, but no less than 2-inch wg.
c. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
d. SMACNA Leakage Class: 3.

C. Intermediate Reinforcement:

1. Galvanized Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. Stainless Steel Ducts: Match duct material.
3. Aluminum Ducts: Match duct material.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two (2) vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Conical tap.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Backdraft and pressure relief dampers.

B. Barometric relief dampers.

C. Manual volume dampers.

D. Control dampers.

E. Fire dampers.

F. Ceiling dampers.

G. Smoke dampers.

H. Combination fire and smoke dampers.

I. Corridor dampers.

J. Flange connectors.

K. Duct silencers.

L. Turning vanes.

M. Remote damper operators.

N. Duct-mounted access doors.

O. Flexible connectors.

P. Flexible ducts.

Q. Duct security bars.

R. Duct accessory hardware.

1.3 RELATED SECTIONS

A. Section 28 31 11 - Digital, Addressable Fire-Alarm System: Duct-mounted fire and smoke detectors.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

E. Source quality-control reports.

F. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with AMCA 500-D testing for damper rating.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless Steel Sheets: Comply with ASTM A480, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.

2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Greenheck Fan Corporation.
6. Lloyd Industries, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. Pottorff; a division of PCI Industries, Inc.
10. Ruskin Company.
11. SEMCO Incorporated.
12. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 1-inch wg.

E. Frame: 0.063-inch thick extruded aluminum, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Aluminum.
2. Diameter: 0.20-inch.

J. Tie Bars and Brackets: Aluminum].

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

    a. Sleeve Thickness: 20-gage minimum.

b. Sleeve Length: Six (6) inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Greenheck Fan Corporation.
6. Lloyd Industries, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. Pottorff; a division of PCI Industries, Inc.
10. Ruskin Company.
11. SEMCO Incorporated.
12. Vent Products Company, Inc.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2000 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.063-inch thick extruded aluminum, with welded corners and mounting flange.

F. Blades:

1. Multiple, 0.025-inch thick, roll-formed aluminum.
2. Maximum Width: Six (6) inches.
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets:

1. Material: Aluminum.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Bronze.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. METALAIRE, Inc.
f. Nailor Industries Inc.
g. Pottorff; a division of PCI Industries, Inc.
h. Ruskin Company.
i. Trox USA Inc.
j. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Hat-shaped, galvanized steel channels, 0.064-inch minimum thickness.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized-steel, 0.064-inch thick.

6. Blade Axles: Galvanized steel.

7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. Flexmaster U.S.A., Inc.
    d. McGill AirFlow LLC.
    e. METALAIRE, Inc.
    f. Nailor Industries Inc.
    g. Pottorff; a division of PCI Industries, Inc.
    h. Ruskin Company.
    i. Trox USA Inc.
    j. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Roll-Formed Aluminum Blades: 0.10-inch thick aluminum sheet.
    e. Extruded-Aluminum Blades: 0.050-inch thick extruded aluminum.

6. Blade Axles: Stainless steel.
7. Bearings:

    a. Stainless steel sleeve.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Air Balance Inc.; a division of Mestek, Inc.
    b. American Warming and Ventilating; a division of Mestek, Inc.
    c. Flexmaster U.S.A., Inc.
    d. McGill AirFlow LLC.
    e. METALAIRE, Inc.
    f. Nailor Industries Inc.
    g. Pottorff; a division of PCI Industries, Inc.
    h. Ruskin Company.
    i. Trox USA Inc.
    j. Vent Products Company, Inc.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames:

    a. Hat shaped.
    b. Galvanized-steel channels, 0.064-inch thick.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, 0.064-inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered aluminum.
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:

a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. Flexmaster U.S.A., Inc.
   d. McGill AirFlow LLC.
   e. METALAIRE, Inc.
   f. Nailor Industries Inc.
   g. Pottorff; a division of PCI Industries, Inc.
   h. Ruskin Company.
   i. Trox USA Inc.
   j. Vent Products Company, Inc.

2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Roll-Formed Aluminum Blades: 0.10-inch thick aluminum sheet.

6. Blade Axles: Stainless steel.
7. Bearings:

   a. Stainless steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered aluminum.
10. Tie Bars and Brackets: Aluminum.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Duro Dyne Inc.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. Lloyd Industries, Inc.
8. M&I Air Systems Engineering; Division of M&I Heat Transfer Products Ltd.
9. McGill AirFlow LLC.
10. METALAIRE, Inc.
11. Metal Form Manufacturing, Inc.
12. Nailor Industries Inc.
13. NCA Manufacturing, Inc.
14. Ruskin Company.
15. Vent Products Company, Inc.
16. Young Regulator Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Hat shaped.
2. Galvanized steel channels, 0.064-inch thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Opposed-blade design.
3. Galvanized steel.
4. 0.064-inch thick.

5. Blade Edging: Closed-cell neoprene edging.

E. Blade Axles: 1/2-inch diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 degrees F.

F. Bearings:

1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. PHL, Inc.
10. Pottorff; a division of PCI Industries, Inc.
11. Prefco; Perfect Air Control, Inc.
12. Ruskin Company.
13. Vent Products Company, Inc.
14. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours. Coordinate rating requirements with the Architectural contract documents.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052- or 0.138-inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 degrees F rated, fusible links.

K. Heat-Responsive Device: Electric resettable link and switch package, factory installed, 165 degrees F rated.

2.7 CEILING DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. McGill AirFlow LLC.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. Prefco; Perfect Air Control, Inc.
7. Ruskin Company.
8. Vent Products Company, Inc.
9. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, 165 degrees F rated, fusible links.

F. Fire Rating: Two (2) hours.

2.8 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. PHL, Inc.
6. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized steel blade connectors.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.052-inch thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

I. Damper Motors: Modulating or two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 00 and in Division 26 sections.

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F.
6. Non-spring-Return Motors: For dampers larger than 25 sq ft, size motor for running torque rating of 150 in x lbf and breakaway torque rating of 300 in x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Test and reset switches, remote mounted.

2.9 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours. Coordinate rating requirements with the Architectural contract documents.

E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

G. Smoke Detector: Integral, factory wired for single-point connection.

H. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

I. Blades: Roll-formed, horizontal, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized steel blade connectors.

J. Leakage: Class I.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.052-inch thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

M. Damper Motors: two-position action.

N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in x lbf and breakaway torque rating of 150 in x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F.
6. Non-spring-Return Motors: For dampers larger than 25 sq ft, size motor for running torque rating of 150 in x lbf and breakaway torque rating of 300 in x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

O. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Test and reset switches, remote mounted.

2.10 CORRIDOR DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.
4. Ruskin Company.

B. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-1/2-hour rating by an NRTL.

C. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized steel blade connectors.

F. Mounting Sleeve: Factory-installed, 0.052-inch thick, galvanized sheet steel; length to suit wall or floor application.

G. Damper Motors: Modulating or two-position action.

H. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 00 & Division 26 sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in x lbf and breakaway torque rating of 150 in x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 degrees F.
6. Non-spring-Return Motors: For dampers larger than 25 sq ft, size motor for running torque rating of 150 in x lbf and breakaway torque rating of 300 in x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

2.11 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.12 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Industrial Noise Control, Inc.
2. McGill AirFlow LLC.
3. Price Industries.
4. Ruskin Company.
5. Vibro-Acoustics.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A653, G90, galvanized sheet steel, 0.034-inch thick.

E. Round Silencer Outer Casing: ASTM A653, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034-inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040-inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.052-inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064-inch thick.

F. Inner Casing and Baffles: ASTM A653, G90 galvanized sheet metal, 0.034-inch thick, and with 1/8-inch diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative or Film-lined type with fill material.

    a. Fill Material: Moisture-proof non-fibrous material.
    b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: Tedlar.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Flange connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Integral 1-1/2 or 3-hour fire damper with access door, as required. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.

L. Source Quality Control: Test according to ASTM E477.

1. Testing of mockups to be witnessed by Architect.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.13 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 24 inches wide and double wall for larger dimensions.

2.14 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Metropolitan Air Technology, LLC.
2. Pottorff; a division of PCI Industries, Inc.

3. Ventfabrics, Inc.
4. Young Regulator Company.

B. Description: Rotary Cable system designed for remote manual damper adjustment located in inaccessible locations and where otherwise indicated on the contract drawings. Refer to Architectural drawings for coordination of finished surfaces. Damper shall be capable of being actuated, internally or externally, of the ductwork. Provide duct seal plates where cables run through the duct wall. Where the operators are located behind diffusers, registers or grilles, the damper shall be adjustable with the use of standard tools.

C. Tubing: Brass.

D. Cable: Brass plated steel. Cable shall have a minimum torque service factor of 200% when install in accordance with the manufacturers written instructions.

1. Provide custom lengths, as required, for connections between the operators and their respective dampers to allow for easy access to the operators. Coordinate operator locations with the Architectural Division. Provide nylon cable clamps as required per manufacturers installations instructions and recommendations.
2. Cable shall be capable of being field cut to shorten if excess cable length is too great.

E. Ceiling or Wall-Box Mounting: Recessed, 3/4 inches deep or recessed, two (2) inches deep to suit project requirements. Security type with tamperproof screws.

F. Ceiling or Wall-Box Cover-Plate Material: Stainless steel. Color to be coordinated with the Architectural Division.

G. Dampers:

1. Square/Rectangular: Extruded aluminum, opposed blade – spring loaded to hold setting. Rotary actuated damper. Extruded aluminum bearing bracket. Cable assembly shall snap-fit into damper for one piece installation with no linkage adjustment required

   a. Single operator size limits: 6”x4” thru 24”x18”. For application where larger ducts are required, provide multiple damper and cable assemblies as required. The mechanical contractor shall coordinate.

2. Round: Galvanneal steel radial damper velocity loaded to hold setting. Damper pivot to accept rotary cable. Direct actuated.

2.15 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Flexmaster U.S.A., Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Pottorff; a division of PCI Industries, Inc.
9. Ventfabrics, Inc.
10. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two (2) sash locks.
b. Access Doors up to 18 Inches Square: Two (2) hinges and two (2) sash locks.
c. Access Doors up to 24 by 48 Inches: Three (3) hinges and two (2) compression latches.
d. Access Doors Larger Than 24 by 48 Inches: Four (4) hinges and two (2) compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.

3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 10-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.16 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel to match duct system it serves.

D. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 degrees F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.17 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two (2) strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz/sq yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 degrees F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz/sq yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 degrees F.

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz/sq yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 degrees F.

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz/sq yd.
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 degrees F.

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.18 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Non-insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 degrees F.

C. Non-insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 degrees F.

D. Non-insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 degrees F.

E. Non-insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 degrees F.

F. Non-insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 100 to plus 435 degrees F.

G. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 degrees F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004.

H. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes three (3) through 18 inches, to suit duct size.
2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.19 DUCT SECURITY BARS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Carnes.
2. KEES, Inc.
3. Lloyd Industries, Inc.
4. Metal Form Manufacturing, Inc.
5. Price Industries.

B. Description: Field- or factory-fabricated and field-installed duct security bars.

C. Configuration:

1. Frame: 10 gage by 2 inches.
2. Sleeve: 3/16-inch, continuously welded steel frames with 1-by-1-by-3/16-inch angle frame factory welded to one (1) end. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
3. Horizontal Bars: 1/2-inch.
4. Vertical Bars: 1/2-inch.
5. Bar Spacing: Six (6) inches.
6. Mounting: Bolted or welded.

2.20 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch diameter steel bars, six (6) inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to four (4) sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

I. Connect ducts to duct silencers rigidly.

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.

5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

M. Label access doors according to Section 23 05 53 to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly.

Q. Connect diffusers or light troffer boots to ducts directly.

R. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

S. Install duct test holes where required for testing and balancing purposes.

T. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Airfoil centrifugal fans.

B. Backward-inclined centrifugal fans.

C. Forward-curved centrifugal fans.

D. Plenum fans.

E. Plug fans.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 05 00 - Common Work Results for HVAC.

C. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

D. Section 23 05 48 - Vibration & Seismic Controls for HVAC Piping & Equipment.

E. Section 23 05 53 - Identification for HVAC Piping & Equipment.

F. Section 23 05 93 - Testing, Adjusting, & Balancing for HVAC.

G. Section 23 08 00 - Commissioning of HVAC.

H. Section 23 33 00 - Air Duct Accessories.

I. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables.

J. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

1.4 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on actual project site elevations above sea level.

B. Operating Limits: Classify according to AMCA 99.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

D. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One (1) set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 AIRFOIL CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. ABB Fan Group North America.
2. Acme Engineering & Mfg. Corp.
3. Aerovent; a Twin City Fan Company.

4. Airmaster Fan Co.
5. Ammerman; General Resource Corp.
6. Bayley Fans; a division of Lau Industries, Inc.
7. Carrier Corporation.
8. Central Blower Company.
9. Chicago Blower Corporation.
10. Cincinnati Fan.
11. CML Northern Blower Inc.
12. Greenheck
13. Howden Fan Co.
14. Industrial Air; a division of Lau Industries, Inc.
15. Loren Cook Company.
16. Madison Manufacturing.
17. New Philadelphia Fan Co.
18. New York Blower Company (The).
19. Trane.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontally split, bolted-flange housing.
3. Spun inlet cone with flange.
4. Outlet flange.

D. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.

2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
6. Motor Mount: Adjustable for belt tensioning.

J. Accessories:

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99.

8. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

K. Motors: Comply with requirements in Section 23 05 13.

1. Enclosure Type: Totally enclosed, fan cooled.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. ABB Fan Group North America.
2. Acme Engineering & Mfg. Corp.
3. Aerovent; a Twin City Fan Company.
4. Airmaster Fan Co.
5. Ammerman; General Resource Corp.
6. Bayley Fans; a division of Lau Industries, Inc.
7. Carrier Corporation.
8. Central Blower Company.
9. Chicago Blower Corporation.
10. Cincinnati Fan.
11. CML Northern Blower Inc.
12. Greenheck
13. Howden Fan Co.
14. Industrial Air; a division of Lau Industries, Inc.
15. Loren Cook Company.
16. Madison Manufacturing.
17. New Philadelphia Fan Co.
18. New York Blower Company (The).
19. Trane.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontally split, bolted-flange housing.
3. Spun inlet cone with flange.
4. Outlet flange.

D. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

6. Motor Mount: Adjustable for belt tensioning.

J. Accessories:

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99.
8. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

K. Motors: Comply with requirements in Section 23 05 13.

1. Enclosure Type: Totally enclosed, fan cooled.

2.3 FORWARD-CURVED CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. ABB Fan Group North America.
2. Acme Engineering & Mfg. Corp.
3. Aerovent; a Twin City Fan Company.
4. Airmaster Fan Co.
5. Ammerman; General Resource Corp.
6. Bayley Fans; a division of Lau Industries, Inc.
7. Carrier Corporation.
8. Central Blower Corporation.
9. Chicago Blower Corporation.
10. Cincinnati Fan.
11. CML Northern Blower Inc.
12. Greenheck
13. Howden Fan Co.
14. Industrial Air; a division of Lau Industries, Inc.
15. Loren Cook Company.
16. Madison Manufacturing.
17. New Philadelphia Fan Co.

18. New York Blower Company (The).
19. Trane.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontally split, bolted-flange housing.
3. Spun inlet cone with flange.
4. Outlet flange.

D. Forward-Curved Wheels: Black-enameled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

E. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
6. Motor Mount: Adjustable for belt tensioning.

J. Accessories:

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99.
8. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

K. Motors: Comply with requirements in Section 23 05 13.

1. Enclosure Type: Totally enclosed, fan cooled.

2.4 PLENUM FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. ABB Fan Group North America.

2. Acme Engineering & Mfg. Corp.
3. Aerovent; a Twin City Fan Company.
4. Airmaster Fan Co.
5. Ammerman; General Resource Corp.
6. Bayley Fans; a division of Lau Industries, Inc.
7. Carrier Corporation.
8. Central Blower Company.
9. Chicago Blower Corporation.
10. Cincinnati Fan.
11. CML Northern Blower Inc.
12. Greenheck
13. Howden Fan Co.
14. Industrial Air; a division of Lau Industries, Inc.
15. Loren Cook Company.
16. Madison Manufacturing.
17. New Philadelphia Fan Co.
18. New York Blower Company (The).
19. Trane.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

F. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
6. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Spark-Resistant Construction: AMCA 99.
3. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Section 23 05 13.

1. Enclosure Type: Totally enclosed, fan cooled.

2.5 PLUG FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. ABB Fan Group North America.
2. Acme Engineering & Mfg. Corp.
3. Aerovent; a Twin City Fan Company.
4. Airmaster Fan Co.
5. Ammerman; General Resource Corp.

6. Bayley Fans; a division of Lau Industries, Inc.
7. Carrier Corporation.
8. Central Blower Company.
9. Chicago Blower Corporation.
10. Cincinnati Fan.
11. CML Northern Blower Inc.
12. Greenheck
13. Howden Fan Co.
14. Industrial Air; a division of Lau Industries, Inc.
15. Loren Cook Company.
16. Madison Manufacturing.
17. New Philadelphia Fan Co.
18. New York Blower Company (The).
19. Trane.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

C. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

F. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, Ll0 at 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, Ll0 at 120,000 hours.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
6. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Spark-Resistant Construction: AMCA 99.
3. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Section 23 05 13.

1. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Support floor-mounting units using restrained spring isolators having a static deflection of one (1) inch. Vibration- and seismic-control devices are specified in Section 23 05 48.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00.

D. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of one (1) inch. Vibration-control devices are specified in Section 23 05 48.

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 23 05 53.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00.

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

D. Ground equipment according to Section 26 05 26.

E. Connect wiring according to Section 26 05 19.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Refer to Section 23 05 93 for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 23 05 93 for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys, sheaves, belts, etc… as required to achieve design airflow.

E. Lubricate bearings.

3.5 COMMISSIONING

A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of commissioning Section 01 91 03.

B. Verify that equipment is installed in accordance with Section 01 91 03 and manufacturer's written instructions.

C. Complete installation and startup checks and functional tests in accordance with Section 01 91 03 and manufacturer's written instructions.

D. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Utility set fans.

B. Centrifugal roof ventilators.

C. Axial roof ventilators.

D. Upblast propeller roof exhaust fans.

E. Centrifugal wall ventilators.

F. Ceiling-mounting ventilators.

G. In-line centrifugal fans.

H. Propeller fans.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 05 00 - Common Work Results for HVAC.

C. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

D. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

E. Section 23 08 00 - Commissioning of HVAC.

1.4 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

D. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One (1) set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Aerovent; a Twin City Fan Company.
2. Carnes Company HVAC.
3. Loren Cook Company.
4. Penn Ventilation.

B. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

C. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

D. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel or Aluminum].
2. Blade Type: Backward inclined, Forward curved or Airfoil.

E. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

F. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Access Door: Gasketed door in scroll with latch-type handles.
4. Inlet Screens: Removable wire mesh.
5. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
6. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.

7. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Carnes Company HVAC.
4. Loren Cook Company.
5. Penn Ventilation.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
2. Hinged Subbase: Galvanized steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

F. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Variable-Speed Controller: Units requiring a speed controller will be called out on the Mechanical Schedules in the contract drawings. Refer to those for specific applications. When utilized, variable speed controllers to have solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

3. Bird Screens: Removable, 1/2-inch mesh, aluminum.
4. Motorized Dampers: Opposed-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: aluminum; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches minimum; 16 inches minimum for curbs including sound attenuation inserts. Coordinate height requirements with fan and curb options.
3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.
7. Vented Curb: Unlined with louvered vents in vertical sides.

2.3 AXIAL ROOF VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Carnes Company HVAC.
4. Loren Cook Company.
5. Penn Ventilation.

B. Description: Direct- or belt-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheel: Aluminum or Steel hub and blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

F. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Motorized Dampers: Opposed-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: aluminum; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches minimum; 16 inches minimum for curbs including sound attenuation inserts. Coordinate height requirements with fan and curb options.
3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.
7. Vented Curb: Unlined with louvered vents in vertical sides.

2.4 UPBLAST PROPELLER ROOF EXHAUST FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Carnes Company HVAC.
4. Loren Cook Company.
5. Penn Ventilation.

B. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Wind Band, Fan Housing, and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

1. Damper Rods: Steel with bronze or nylon bearings.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

F. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit. For DS outside of fan housing provide weatherproof NEMA switch to match application.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Motorized Dampers: Opposed-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

G. Roof Curbs: Aluminum; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches minimum; 16 inches minimum for curbs including sound attenuation inserts. Coordinate height requirements with fan and curb options.
3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.

2.5 CENTRIFUGAL WALL VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Carnes Company HVAC.
4. Loren Cook Company.
5. Penn Ventilation.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

C. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

D. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

F. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Opposed-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.6 CEILING-MOUNTING VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Carnes Company HVAC.
2. Loren Cook Company.
3. Penn Ventilation.

B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Filter: Washable aluminum to fit between fan and grille.
6. Isolation: Rubber-in-shear vibration isolators.
7. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.7 IN-LINE CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

Non-BOD Manufacturers

1. Acme Engineering & Mfg. Corp.
2. Carnes Company HVAC.
3. Loren Cook Company.
4. Penn Ventilation.

B. Description: In-line, direct or belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

G. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Companion Flanges: For inlet and outlet duct connections.
3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.8 PROPELLER FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Carnes Company HVAC.
4. Loren Cook Company.
5. Penn Ventilation.

B. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

C. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

D. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

E. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

F. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through five (5) hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories: (Coordinate requirements with the Fan schedules for any additional requirements)

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2.9 MOTORS

A. Comply with requirements in Section 23 05 13.

2.10 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using restrained spring isolators having a static deflection of one (1) inch. Vibration- and seismic-control devices are specified in Section 23 05 48.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00.

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Section 07 72 00 for installation of roof curbs.

E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

F. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of one (1) inch. Vibration-control devices are specified in Section 23 05 48.

G. Install units with clearances for service and maintenance.

H. Label units according to requirements specified in Section 23 05 53.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 26 05 26.

D. Connect wiring according to Section 26 05 19.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Section 23 05 93 for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys, sheaves, belts, etc… as required to achieve design airflow.

E. Lubricate bearings.

3.5 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 8 hours to train Owner's maintenance personnel to adjust, operate, and maintain HVAC power ventilators. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Shutoff, single-duct air terminal units.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems".

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.
2. Liners and adhesives.
3. Sealants and gaskets.
4. Seismic-restraint devices.

C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

F. Field quality-control reports.

G. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:

1. Anemostat Products; a Mestek Company.
2. Carnes.
3. Environmental Technologies, Inc.
4. Krueger.
5. METALAIRE, Inc.
6. Price Industries.
7. Trane; a business of American Standard Companies.
8. Tuttle & Bailey.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel, double wall.

1. Casing Lining: Adhesive attached, 1-inch thick, coated, fibrous-glass duct liner complying with ASTM C1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84.
   a. Cover liner with nonporous foil and perforated metal.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, two (2) percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally closed.

E. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1-inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 degrees F. Include manual air vent and drain valve.

F. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 23 09 00 and shall have the following features:

1. Damper Actuator: 24 V, powered closed, powered open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 23 09 00.

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

2.2 HANGERS AND SUPPORTS

A. Hanger Rods for Non-corrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Galvanized steel complying with ASTM A603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.3 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A603 galvanized steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A-2012, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports - 2005."

B. Building Attachments: Concrete inserts, or structural steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 23 21 13, connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange. Refer to details on the contract drawings for additional information.

C. Connect ducts to air terminal units according to Section 23 31 13.

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer’s written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer’s written instructions/requirements.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Round ceiling diffusers.

B. Rectangular and square ceiling diffusers.

C. Louver face diffusers.

D. Linear bar diffusers.

E. Linear slot diffusers.

F. Ceiling-integral continuous diffusers.

G. Drum louvers.

H. Modular core supply grilles.

I. Adjustable bar registers and grilles.

J. Fixed face registers and grilles.

K. Linear bar grilles.

1.3 RELATED SECTIONS

A. Section 08 90 00 - Louvers and Vents: Fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.

B. Section 23 33 00 - Air Duct Accessories: Fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

C. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:

1. Air Research Diffuser Products, Inc.
2. A-J Manufacturing Co., Inc.
3. Anemostat Products; a Mestek company.
4. Carnes.
5. Hart & Cooley Inc.
6. Krueger.
7. METALAIRE, Inc.
8. Nailor Industries Inc.
9. Price Industries.
10. Titus.
11. Tuttle & Bailey.
12. Warren Technology.

2.2 CEILING DIFFUSERS

A. Round Ceiling Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Style: Four, Three, or Two cone.
5. Mounting: Duct connection.
6. Pattern: Fully adjustable.
7. Dampers: Combination damper and grid.
8. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

B. Rectangular and Square Ceiling Diffusers:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Size: 24 by 24.
5. Face Style: Three (3) cone, Four (4) cone, or Plaque.
6. Mounting: Refer to contract drawings. The mechanical contractor shall coordinate with the Architectural reflected ceiling plans.
7. Pattern: Fixed.
8. Dampers: Combination damper and grid.
9. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

C. Louver Face Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Size: Refer to contract drawings.
5. Mounting: Refer to contract drawings.

6. Pattern: Refer to contract drawings.
7. Dampers: Combination damper and grid.
8. Accessories:

    a. Square to round neck adaptor.
    b. Adjustable pattern vanes.
    c. Throw reducing vanes.
    d. Equalizing grid.
    e. Plaster ring.
    f. Safety chain.
    g. Wire guard.
    h. Sectorizing baffles.
    i. Operating rod extension.

2.3 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Frame: Refer to contract drawings.
5. Mounting: Refer to contract drawings. The mechanical contractor shall coordinate with the Architectural reflected ceiling plans.
6. Damper Type: Adjustable opposed-blade assembly.
7. Accessories:

    a. Plaster frame
    b. Directional vanes
    c. Alignment pins
    d. Core clips
    e. Blank-off strips.

B. Linear Slot Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material - Shell: Steel or Aluminum, non-insulated.
3. Material - Pattern Controller and Tees: Aluminum.
4. Finish - Face and Shell: Baked enamel, black.
5. Finish - Pattern Controller: Baked enamel, black.
6. Finish - Tees: Baked enamel, color selected by Architect.
7. Slot Width: Refer to contract drawings.
8. Number of Slots: Refer to contract drawings.
9. Length: Refer to contract drawings.
10. Accessories:

a. Plaster frame
b. T-bar slot
c. Center notch
d. T-bar on both sides
e. T-bar clips on both sides.

C. Ceiling-Integral Continuous Diffuser:

1. Slot Width: Refer to contract drawings.
2. Section Length: Refer to contract drawings.
3. Straight and curved sections as required to accommodate layout.
4. Mitered tees and corners.
5. Pattern Controllers: 24 inches o.c.
6. Material: Aluminum, extruded, heavy wall.
7. Finishes:

   a. Exterior: Standard white.
   b. Interior: Standard black.

8. Throw: Standard.
9. Mounting: Refer to contract drawings.
10. Plenum: Insulated.
11. Other Features:

    a. Painted interior.
    b. Blank-offs.

2.4 HIGH-CAPACITY DIFFUSERS

A. Drum Louver:

1. Airflow Principle: Extended distance for high airflow rates.
2. Material: Aluminum, heavy gage extruded.
3. Finish: Baked enamel, color selected by Architect.
4. Border: 1-1/4-inch width with countersunk screw holes.
5. Gasket between drum and border.
6. Body: Drum shaped; adjustable vertically.
7. Blades: Individually adjustable horizontally.
8. Mounting: Refer to contract drawings.
9. Accessories:

   a. Opposed-blade steel damper.
   b. Duct-mounting collars with countersunk screw holes.

B. Modular Core Supply Grilles:

1. Throw: Extended distance for airflow rates.
2. Material: Steel.
3. Grilles per Unit: Refer to contract drawings.
4. Finish: Baked enamel, color selected by Architect.
5. Border: 1-1/2-inch width with countersunk screw holes.
6. Blades:

    a. Airfoil, individually adjustable horizontally.
    b. Double deflection.
    c. Set in modules.

7. Modules: Removable; rotatable.
8. Mounting: Surface.
9. Accessory: Opposed-blade steel damper.

2.5 REGISTERS AND GRILLES

A. Adjustable Bar Register:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Face Blade Arrangement: Horizontal**,** Refer to contract drawings.
4. Core Construction: Integral.
5. Rear-Blade Arrangement: Vertical, Refer to contract drawings.
6. Frame: 1-inch wide.
7. Mounting: Refer to contract drawings.
8. Damper Type: Adjustable opposed blade.
9. Accessories:

    a. Rear-blade gang operator.
    b. Filter.

B. Adjustable Bar Grille:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Face Blade Arrangement: Horizontal**,** Refer to contract drawings.
4. Core Construction: Integral.
5. Rear-Blade Arrangement: Vertical, Refer to contract drawings.
6. Frame: 1-inch wide.
7. Mounting: Refer to contract drawings.

C. Fixed Face Register:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.

3. Face Blade Arrangement: Horizontal**,** Refer to contract drawings.
4. Core Construction: Integral.
5. Rear-Blade Arrangement: Vertical, Refer to contract drawings.
6. Frame: 1-inch wide.
7. Mounting: Refer to contract drawings.
8. Damper Type: Adjustable opposed blade.

D. Fixed Face Grille:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Face Blade Arrangement: Horizontal**,** Refer to contract drawings.
4. Core Construction: Integral.
5. Rear-Blade Arrangement: Vertical, Refer to contract drawings.
6. Frame: 1-inch wide.
7. Mounting: Refer to contract drawings.
8. Damper Type: Adjustable opposed blade.

E. Linear Bar Grille:
1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Face Arrangement: Refer to contract drawings.
4. Distribution plenum.

a. Internal insulation.
b. Inlet damper.

5. Frame: 1-inch wide.
6. Mounting: Refer to contract drawings.
7. Damper Type: Adjustable opposed blade.

2.6 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Metal panel filters.

B. Flat panel filters.

C. Pleated panel filters.

D. Rigid cell box filters.

E. V-bank cell filters.

F. Front- and rear-access filter frames.

G. Side-service housings.

H. Filter gages.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: For power, signal, and control wiring.

D. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one (1) complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one (1) container(s) of red oil for inclined manometer filter gage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AAF International.
2. Airguard.
3. Camfil Farr.
4. Columbus Industries, Inc.
5. CRS Industries, Inc.; CosaTron Division.
6. D-Mark.
7. Filtration Group.
8. Flanders-Precisionaire.

9. Koch Filter Corporation.
10. Purafil, Inc.
11. Research Products Corp.
12. Tri-Dim Filter Corporation.

2.2 METAL PANEL FILTERS

A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.

B. Media: Six alternate layers of stainless-steel flat and herringbone-crimp screen.

1. Non-oiled for grease removal application.
2. Adhesive coating.

a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Filter-Media Frame: Stainless steel, hinged, and with pull and retaining handles fastened to the media.

1. Drain holes.

2.3 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, non-pleated, panel-type, disposable air filters with holding frames.

B. Filter Unit Class: UL 900, Class 1.

C. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. Metal Retainer: Upstream side and downstream side.

D. Filter-Media Frame: Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. MERV Rating: 7 when tested according to ASHRAE 52.2.

2.4 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

B. Filter Unit Class: UL 900, Class 1.

C. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. Separators shall be bonded to the media to maintain pleat configuration.
4. Welded wire grid shall be on downstream side to maintain pleat.
5. Media shall be bonded to frame to prevent air bypass.
6. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: Aluminized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. MERV Rating: 13 when tested according to ASHRAE 52.2.

2.5 RIGID CELL BOX FILTERS

A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.

B. Filter Unit Class: UL 900, Class 1.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frames: Galvanized steel.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. MERV Rating: 13 when tested according to ASHRAE 52.2.

2.6 V-BANK CELL FILTERS

A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media angled to airflow, and with holding frames.

B. Filter Unit Class: UL 900, Class 1.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frames: Galvanized steel.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. MERV Rating: 13 when tested according to ASHRAE 52.2.

2.7 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Framing System: Galvanized steel framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

B. Prefilters: Incorporate a separate track with spring clips, removable from front or back.

C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.8 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel with flanges to connect to duct or casing system.

B. Prefilters: Integral tracks to accommodate 2-inch- deep, disposable or washable filters.

C. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.9 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Airguard.
   b. Dwyer Instruments, Inc.

2. Diameter: 4-1/2 inches.
3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
5. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: 0- to 2.0-inch wg.
6. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg or Less: 0- to 3.0-inch wg.
7. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within three (3) percent of the full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Air-handling units shall not be used for temporary heating and ventilating unless expressly approved by Owner, in writing. If used during construction, see SMACNA's "IAQ Guidelines for Occupied Buildings under Construction" for procedures to protect HVAC system.

F. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

G. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Operate automatic roll filters to demonstrate compliance with requirements.
2. Test for leakage of unfiltered air while system is operating.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Shell-and-tube heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.

2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

D. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Tube-removal space.

2. Structural members to which heat exchangers will be attached.

C. Seismic Qualification Certificates: For heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

D. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-tube heat exchangers comply with "TEMA Standards."

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

1. Warranty Periods: From date of Substantial Completion.

a. Shell-and-Tube, Heat Exchangers:

1) Tube Coil: One (1) year(s).
2) Other Components: One (1) year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00, to design seismic restraints for heat exchangers.

B. Seismic Performance: Heat exchangers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. For additional performance requirements, refer to Section 23 05 48.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one (1) of the following:

1. API Heat Transfer Inc.

2. Armstrong Pumps, Inc.

3. ITT Corporation; Bell & Gossett.

4. TACO Incorporated.

B. Description: Packaged assembly of tank, heat-exchanger coils, and specialties. The heat exchanger shall be part of an overall package that shall include, but not be limited to: all hydronic and steam specialties, piping, valves, fittings, variable speed drives, disconnects, wiring, controls, equipment, etc…. and all items factory mounted and wired to a galvanized structural steel mounting system. Refer to other spec. sections and the contract drawings for additional info. related to the components noted above.

C. Construction:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Configuration: U-tube with removable bundle.

E. Shell Materials: Steel

F. Head:

1. Materials: Cast iron.

2. Flanged and bolted to shell.

G. Tube:

1. Seamless copper tubes.

2. Tube diameter is determined by manufacturer based on service.

H. Tubesheet Materials: Steel.

I. Baffles: Steel.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.

2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Support Saddles:

1. Fabricated of material similar to shell.

2. Fabricate foot mount with provision for anchoring to support.

3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

L. Capacities and Characteristics: (Refer to schedule on contract drawings)

2.3 ACCESSORIES

A. Hangers and Supports:

1. Factory-fabricated steel supports and cradles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 23 05 29.

B. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Refer to drawings for additional info.

C. Pressure Relief Valves: Cast iron, ASME rated and stamped.

1. Pressure relief valve setting: 100 psig.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SHELL-AND-TUBE HEAT-EXCHANGER INSTALLATION

A. Equipment Mounting:

1. Install heat exchangers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00.

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48.

B. Heat-Exchanger Supports: Use factory-fabricated steel cradles and supports specifically designed for each heat exchanger.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Section 23 21 13 and Section 23 21 16. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam and condensate piping specified in Section 23 22 13 and Section 23 22 16.

C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

E. Install shutoff valves at heat-exchanger inlet and outlet connections.

F. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

G. Install vacuum breaker at heat-exchanger steam inlet connection.

H. Install hose end valve to drain shell.

I. Install thermometer on heat-exchanger and inlet and outlet piping, and install thermometer on heating-fluid inlet piping. Comply with requirements for thermometers specified in Section 23 05 19.

J. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 23 05 19.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Packaged, outdoor, central-station air-handling units with the following components and accessories as a minimum:

1. Supply-air fan section.
2. Return-air fan section.
3. Chilled water cooling and Hot water heating coil sections.
4. Filter section(s).
5. Mixing section.
6. Dampers.
7. Unit mounted sound attenuators in the supply air and return air streams.
8. Airflow monitoring stations.
9. Single point power connection with unit disconnect, motor starters and variable frequency drives.
10. General lighting and convenience receptacles.
11. Roof Curbs.

B. All components and accessories are to be factory mounted and wired, unless otherwise noted.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 00 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 03 - Commissioning.

F. Section 07 72 00 - Roof Accessories.

G. Section 23 05 00 - Common Work Results for HVAC.

H. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

I. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

J. Section 23 07 00 - HVAC Insulation.

K. Section 23 08 00 - Commissioning of HVAC.

L. Section 23 09 00 - Instrumentation & Control for HVAC.

M. Section 23 09 93 - Sequence of Operations for HVAC Controls.

N. Section 23 21 13 - Hydronic Piping.

O. Section 23 41 00 - Particulate Air Filtration.

P. Section 26 29 13 - Enclosed Controllers: Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

Q. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1. Variable-frequency motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

1.4 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. AHU: Air Handling unit. As used in this section, this abbreviation means outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.6 QUALITY

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for AHUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

D. UL Compliance: Comply with UL 1995.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1. All unit mounted devices shall be at a height above the finished roof to assure access without the use of ladders by the owner’s maintenance personnel.

F. Service for the unit shall be available locally either directly from the manufacturer or from the manufacturer’s certified local representative.

G. The unit shall comply with the requirements of the Buy American Act and be defined as a domestic end product as per the two part test described therein.

H. Components not manufactured at the factory shall be provided by manufacturers regularly engaged in the production of such equipment and shall conform to recognized industry standards.

I. Units shall be built and shipped in one single piece or in separate modules, as required by the project specification and/or restrictions at the job site.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Units shall be shipped with integral lifting lugs welded to the unit frame. Before leaving the factory, units shall be wrapped, packaged, and sufficiently protected for transportation by truck and outdoor storage. Duct connection openings shall be covered with plywood.

B. Unit should immediately be inspected for any damage that may have occurred during shipping. Care should be used whenever handling the unit to avoid damaging any components, wiring, or the unit surface finish.

C. Although the unit packaging is weather resistant, if the unit is not to be immediately installed, it should be stored in a dry place protected from weather, traffic, and unauthorized personnel.

D. If the unit is to be stored for any length of time, it must be supported and cribbed along the full length of its support channel. Major support should be provided at the perimeter of the unit and at the furnace section. The unit can rest on the angle iron perimeter frame, but should not be supported where there is no framing underneath.

E. If the unit is not immediately installed and run, the blower bearings should be regreased and wrapped with plastic. After each month of storage the bearings should be purged with new grease to remove any accumulated moisture.

F. If the blowers are not regularly run, the blower wheels should be manually rotated every two weeks to redistribute the grease and prevent flat spots from developing on the bearings.

1.8 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include manufacturer's technical data for each AHU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

C. Sustainable Design Submittals:

1. Product Data: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

E. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Manufacturer Seismic Qualification Certification: Submit certification that AHUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which AHUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For AHUs to include in emergency, operation, and maintenance manuals.

J. Warranty: Special warranty specified in this section.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of AHUs that fails in materials or workmanship for two years, except as otherwise noted below, from substantial completion.

1. Control Boards: Three (3) years.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One (1) set for each belt-driven fan.
2. Filters: One (1) set of filters of each filter type for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Trane (Basis of Design)
2. McQuay
3. AAON

2.2 CASING

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

1. The unit panels shall be galvanized steel double wall construction. The casing shall be able to withstand up to six (6) inches of static pressure with no more than 0.005-inch deflection per inch of panel span. The entire length and width under the base is sealed for additional water management protection. Panels feature solid double wall construction with totally enclosed closed-cell insulation.
2. Units may be shipped fully assembled up to nominal 25,000 cfm units or disassembled to the minimum component size according to shipping or jobsite requirements. Units shipped in one piece will have no more than 6 points of lift required. These lift points will be permanently attached to the unit base and be

designed to accept standard rigging devices. Units shipped in sections will have no more than 4 points of lift required. Units are UL and CUL listed L1995, CSA C-22.2 as manufactured by the factory. Modifications to the units at the job site or by a third party may void this listing.

B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

1. Unit roof is constructed of two pieces. Inner roof is installed in such a manner as to prevent air bypass between internal components. Outer roof is sloped either from one side of unit to the other or from center to sides of the unit. Roof assembly overhangs all walls of units by two (2) inches minimum.
2. External surfaces of all unit casings shall be prepared and painted. Color to be standard "Slate Gray". Paint system shall have been tested in accordance with ASTM B117 for a minimum of 500 consecutive hours and shall meet the following requirements following the salt-spray test:

    a. Mean scribe creepage rating of at least six (6) per ASTM D1654 Procedure A.
    b. Blister size no larger than #6 per ASTM D714.
    c. Blister density no greater than Medium per ASTM D714.
    d. No onset of red rust.

3. Exterior Casing Thickness: 0.0626-inch thick.

C. External Pipe Cabinet:

1. A piping cabinet with access door is supplied factory assembled of the same construction as the main unit casing. Piping cabinets are shipped separately for field installation on the side of the unit.

D. Inner Casing Fabrication Requirements:

1. Inside Casing: Galvanized steel, 0.028-inch thick.

E. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C1071, Type I.
2. Provide a minimum R-value of 12.
3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C916, Type I.

F. Condensate Drain Pans: Formed sections of stainless steel sheet, a minimum of two (2) inches deep, and complying with ASHRAE 62.1-2004.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

H. Access Doors: Access doors are fully insulated double-wall construction (with solid galvanized steel interior panels). Automotive style neoprene gasket around the full perimeter of the access doors to minimize air leakage. All access doors have a single door handle system.

I. External Pipe Cabinet: Piping cabinet is supplied by the manufacturer factory assembled and constructed the same as the main unit casing. Piping cabinet is mounted external to the unit and shipped separate to be field installed.

J. Blank / Access / Inspection: Additional unit length is provided to allow extra interior space for, access to, or inspection of unit components.

2.3 FANS

A. Fans are factory balanced. Fan shafts are solid, protectively coated with lubricating oil, and designed so fan will not exceed 75 percent of the first critical speed at any cataloged rpm. Fan wheels are keyed to the shaft to prevent slipping. Access doors are provided on the drive side of the fan section. A separate power source is required for each fan section without single point power. Units with single point power require one power source in the supply fan section.

B. The air foil (AF) fan is a double-width, double-inlet, multi-blade type as required for stable operation and optimum energy efficiency. Bearings are self-aligning, antifriction bearings with an L-50 life of 200,000 hours. For any bearing requiring relubrication, the grease line shall be extended to the fan support bracket on the drive side. Fan performance is certified as complying with ARI Standard 430.

C. Sheaves are fixed pitch for constant speed at the specified rpm.

D. Two (2) Inch Spring Isolators - Fan and motor assembly (sizes #10 - #100) is internally isolated from the unit casing with two (2) inch deflection spring isolators. The fan discharge is also isolated from unit casing by a flexible canvas duct. The isolation system is designed to resist loads produced by external forces such as earthquakes and conform to the current requirements for Seismic Zone IV.

E. Inverter balancing. Fan systems will be checked with a variable frequency drive for resonant frequencies. Fans, shafts, and drives will meet vibrations tolerance specs from 25 percent to 100 percent of selected RPM.

F. Fan Options:

1. Door Guards: Expanded metal screen is mounted across door opening to protect fan access.

G. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 48 when fan-mounted frame and RTU-mounted frame are anchored to building structure.

H. Fan Motor: Comply with requirements in Section 23 05 13.

1. The motor is a T-frame, squirrel cage, open drip-proof with horsepower, type, and electrical characteristics as shown on equipment schedule. Motor is mounted inside the unit casing integral to an isolated fan assembly. A slide base permits adjustment of drive belt tension.

2.4 VARIABLE FREQUENCY DRIVES

A. Refer to Section 26 29 23 - Variable-Frequency Drives (VFDs): General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

a. Variable-frequency drives are to be factory mounted and wired.

B. Communications: RS485 interface allows VFD to be used with an external system within a multi-drop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMCS control. Provide capability for VFD to retain these settings within the nonvolatile memory.

2.5 COILS

A. Coils have aluminum plate fins and seamless copper tubes. Fin collars are drawn, belled, and firmly bonded to the tubes by mechanical expansion of the tubes.

B. Coils are installed such that headers and return bends are enclosed by unit casings. Coil casings are a minimum of 16-gage galvanized steel formed end supports, top, and bottom channels. If two (2) or more coils are stacked in the unit, intermediate drain channels are installed between coils to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the airstream of the lower coil.

C. Supply and return headers are clearly labeled on the outside of the unit to ensure that direction of coil water flow is counter to direction of unit airflow. Coils are burst tested to 300 psig and proof tested under water to 200 psig.

D. Tubes are 1/2-inch OD, 0.016-inch thick copper.

E. Tubes are 5/8-inch OD, 0.020-inch thick copper.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

B. Filter section(s) have side access filter racks capable of holding cartridge filters and prefilters, an access door for filter removal, and block-offs as required to prevent air bypass around filters.

C. Prefilter Type:

1. Prefilters are 4-inch thick non-woven fabric, treated with adhesive and continuously laminated to a supported steel wire grid. Filters are capable of operating up to 625 fpm face velocity without loss of filter efficiency and holding capacity. The MERV rating shall be 7 when tested in accordance with ANSI/ASHRAE 52.2.

D. Cartridge Filters:

1. Rigid cartridge filters 12” deep shall be provided. The MERV rating shall be 13 when tested in accordance with ANSI/ASHRAE 52.2. Filters shall consist of high density glass fiber media enclosed in galvanized steel frames with diagonal supports on both the entering and leaving sides.
2. Filters shall be UL Class 2 when tested in accordance with UL Standard 900.
3. Filters shall be provided with side-loading frames. Filter holding frames shall be constructed of galvanized steel and equipped with foam gaskets to seal filters against filter frames. Frame seams shall be sealed to eliminate air bypass. Filter holding frames shall be of a universal type to accommodate standard filters of the same nominal size as well as appropriate fasteners.

2.7 DAMPERS

A. Outdoor-, Return-, and relief/exhaust-Air Dampers: Parallel- or opposed-blade galvanized steel dampers.

1. Dampers modulate the volume of outside, return, or relief/exhaust air. Dampers shall be double skin air foil blades, ultra low-leak metal compressible jamb seals,

and extruded vinyl blade edge seals. The dampers shall be rated for a maximum leakage rate of three (3) (cfm)/(foot squared) at one (1) inch wg and eight (8) (cfm)/(foot squared) at four (4) inch wg. Blades rotate on stainless steel sleeve bearings.

2. Damper Motor(s): Provided by the BMCS Contractor, in the field.

    a. A separate damper motor for each damper to operate independently of each other. Connecting rods between dampers are not acceptable.

2.8 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit. All fans wheel shall be included in the single point power connection.

1. For air handling units requiring both a supply and return/exhaust fan, the unit manufacturer shall supply single point power wiring to both factory installed and tested fan motor starters or variable frequency drives. On units supplied with starters on both fan motors, both motor starters shall be installed in the supply fan high voltage electrical enclosure. If both fans do not have starters, then individual high voltage enclosures will be supplied for both the supply and return/exhaust fans. Single point power wiring shall include a high voltage distribution block and main unit disconnect with lockout/tagout capabilities. Single point power wiring shall not compromise the UL or ETL certification of the unit.
2. The mechanical contractor shall coordinate a separate 115-V power feed to each AHU to serve the convenience outlets and the lighting. High voltage wiring shall be done through flexible conduit. This power shall be available when the AHU's main unit disconnect has been locked-out.

B. High voltage wiring from either a wiring raceway/trough or directly from a motor starter or variable frequency drive to the air handling unit motor(s) shall be done through flexible conduit. Wiring through conduit shall not compromise the UL or ETL certification of the unit.

2.9 CONTROLS

A. All control end devices (i.e. Damper motors, temperature and pressure sensors/transmitters, low and line voltage wiring, controllers, etc…) are to be furnished and installed by the BMCS contractor.

B. Control equipment and sequence of operation are specified in Section 23 09 00 & 23 09 93, except as otherwise indicated.

2.10 ACCESSORIES

A. Airflow Monitoring Stations (AFMS): AFMS are specified in Section 23 09 00 and will be field installed by the BMCS contractor.

B. Sound attenuators.

C. Duplex, 115-V, ground-fault-interrupter outlet(s) with 15-A overcurrent protection. Coordinate location of outlet(s) to allow for easy access from anywhere around its respective AHU. Where a single outlet is not fully accessible, provide multiple outlets as required. Power circuit(s) shall be wired by the AHU Manufacturer to a common junction box separate from the VFD or starter so the receptacle(s) can remain on when the main disconnect to the unit is on or off.

D. Lights: Factory installed in all accessible module(s). All light(s) will be factory wired to and controlled by a switch in each respective section. Switches shall be provided with a pilot light. Lighting circuit(s) shall be wired by the AHU Manufacturer to a common junction box separate from the VFD or starter so the lights can remain on when the main disconnect to the unit is on or off.

2.11 ROOF CURBS

A. Roof curbs with wind and seismic restraints are specified in Section 07 72 00.

B. Curb Height: 18 inches (min) to curb top rail, unless otherwise noted. Dimension from the finished roof surface and not the building structural steel, corrugated or concrete decking. Refer to details.

C. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match AHU, used to anchor unit to the curb, and designed for loads at project site. Comply with requirements in Section 23 05 48 for wind-load requirements.

PART 3 - EXECUTION

3.1 SHIPPING

A. Paper copies of the IOM shall also be shipped with each AHU.

B. The AHU Manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU Manufacturer shall place them in containers.

C. To protect equipment during shipment and delivery, all outdoor units shall be completely shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.

D. After loading the equipment for shipment, the AHU Manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

3.2 ON-SITE STORAGE

A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

3.3 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of AHUs.

B. Examine roughing-in for AHUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where AHUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 LEVELING

A. The Mechanical Contractor shall laser level all unit mounting surfaces, including housekeeping pads, roof curbs, and/or structural steel prior to rigging and installation of the AHU units. Should the AHU units be installed on an unlevel surface, the Mechanical Contractor shall rework the installation at his/her own expense and to the satisfaction of the Owner and Engineer and to ensure proper installation.

3.5 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install AHUs on curbs and coordinate roof

penetrations and flashing with roof construction specified in Section 07 72 00. Secure AHUs to upper curb rail, and secure curb base to roof framing.

B. Unit Support (Where indicated): Install unit level on structural platform, curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure AHUs to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23 05 48.

D. The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or -welded joints, and all other installation and assembly requirements.

E. The AHU Manufacturer shall provide all screws and gaskets for joining of sections in the field.

F. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU Manufacturer's final inspection and start-up:

1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
3. All water and steam piping connections have been completed and hydrostatically tested and all waterflow rates have been set in accordance with the capacities scheduled on the Drawings.
4. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
5. All power wiring, including motor starters and disconnects, serving the unit has been completed.
6. All automatic temperature and safety controls have been completed.
7. All dampers are fully operational.
8. All shipping materials have been removed.
9. All (clean) filter media has been installed in the units.

3.6 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to AHU coils to allow service and maintenance.

C. Duct installation requirements are specified in other Division 23 sections. Drawings indicate the general arrangement of ducts.

1. Connect supply ducts to AHUs with flexible duct connectors specified in Section 23 33 00.
2. Where ductwork is connected to unit bottom connections (see drawings for unit connections), the following are specific connection requirements:

a. Install ducts to termination at top of roof curb.
b. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
c. Install ducts continuously through roof structure.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections:

1. After installing AHUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.

8. Remove packing from vibration isolators.
9. Verify lubrication on fan and motor bearings.
10. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
11. Adjust fan belts to proper alignment and tension.
12. Start unit according to manufacturer's written instructions.

    a. Complete startup sheets and attach copy with Contractor's startup report.

13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for an initial period as recommended or required by manufacturer.
15. Calibrate thermostats.
16. Adjust and inspect high-temperature limits.
17. Inspect dampers for proper stroke.
18. Start system and measure and record the following:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
20. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve. Replace fan and motor pulleys as required to achieve design conditions.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief/exhaust-air volume.
    d. Outdoor-air intake volume.

21. Verify operation of operation and failure modes. Inspect the following:

    a. Low-temperature safety operation.
    b. Filter high-pressure differential alarm.
    c. Economizer to minimum outdoor-air changeover.
    d. Relief-air fan operation.
    e. Smoke and firestat alarms.

22. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing AHU and air-distribution systems, clean filter housings and install new filters.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests in accordance with Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer’s written instructions/requirements.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 40 hours to train Owner's maintenance personnel to adjust, operate, and maintain AHUs. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 16 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 00 – Commissioning .

F. Section 07 72 00 - Roof Accessories.

G. Section 22 21 23 - Facility Natural-Gas Piping.

H. Section 23 05 00 - Common Work Results for HVAC.

I. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

J. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

K. Section 23 07 00 - HVAC Insulation.

L. Section 23 08 00 - Commissioning of HVAC.

M. Section 23 09 00 - Instrumentation & Control for HVAC.

N. Section 23 09 93 - Sequence of Operations for HVAC Controls.

O. Section 23 23 00 - Refrigerant Piping

P. Section 23 41 00 - Particulate Air Filtration.

Q. Section 26 29 13 - Enclosed Controllers: Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

R. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3 SUMMARY

A. This section includes units with integral Indirect Gas-Fired heating and cooling for rooftop installation. Integral cooling source shall be Packaged DX. Airflow arrangement shall be Outdoor Air only. Each unit shall be constructed in a horizontal configuration and shall incorporate additional product requirements as listed in Section 2 of this specification.

1.4 SUBMITTALS

A. Product Data: For each type or model include the following:

B. Complete fan performance curves for Supply Air, with system operating conditions indicated, as tested on an AMCA Certified Chamber.

C. Sound performance data for Supply Air, as tested on an AMCA Certified chamber.

D. Motor ratings, electrical characteristics and motor and fan accessories.

E. Performance ratings for all chilled water or DX coils.

F. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.

G. Estimated gross weight of each installed unit.

H. Installation, Operating and Maintenance manual (IOM) for each model.

I. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.

J. AHRI Certified coil performance ratings with system operating conditions indicated. Ratings shall be in accordance with Standard 410.

K. Color chart including a palette of available standard paint finishes.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain unit with Integral Heating and Cooling with all appurtenant components or accessories from a single manufacturer.

B. Product Options: Drawings must indicate size, profiles and dimensional requirements of unit and are to be based on the specific system indicated. Refer to Division 1 Section “Product Requirements.”

C. Certifications

1. Entire unit shall be ETL Certified per ANSI Z83.4 or ANSI Z83.18 and bear an ETL mark.
2. Coils shall be Recognized Components for ANSI/UL 1995, CAN / CSA C22.2 No 236.05. DX and water coils shall be AHRI Certified per standard 410-2001.
3. Indirect gas-fired heaters shall be ETL Certified as a component of the unit.

1.6 COORDINATION

A. Coordinate size and location of all building penetrations required for installation of each MAU and associated ducting, plumbing and electrical systems.

B. Coordinate sequencing of construction of associated plumbing, HVAC and electrical supply.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of MERV 13 disposable filters for each unit.
2. One set of fan belts

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, indirect-fired makeup air units that fail in materials and installation within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
2. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:

1. Greenheck (Basis-of-Design).
2. Kees, Inc.
3. Trane.

2.2 MANUFACTURED UNITS

A. Unit with Integral Heating and cooling shall be fully assembled at the factory and consist of an insulated metal cabinet, outdoor air intake weatherhood with combination mesh filter and louver, condensate drain pan, P trap, Packaged DX, motorized intake damper, sensors, curb assembly, filter assembly for intake air, supply air blower assembly and an electrical control center. All specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection. Refer to AHU schedule for additional information.

2.3 CABINET

A. Materials: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.

1. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18 gauge G60 galvaneal steel. Base rail is 12 gauge, galvazined (G90) steel.
2. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum14 gauge galvanized (G90) steel.

B. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181

1. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.

a. Thickness: 1 inch (25 mm)
b. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
c. Location and application: Floor of each unit shall be insulated with 1 inch thick rigid fiberglass insulation, covered on one surface with integral

aluminum foil. Full interior coverage of entire cabinet to include walls and roof of unit shall be semi-rigid type and installed between inner and outer shells of all cabinet exterior components when double walls are specified.

C. Access panels: Unit shall be equipped with insulated, hinged access panels to provide easy access to all major components. Access panels shall be fabricated of 18 gauge galvanized G90 steel. Removable access panels shall incorporate a formed drip edge.

D. Supply Air blower assembly: Blower assembly consists of an electric motor and a belt driven, double width, and double inlet forward curve blower. Assembly shall be mounted on heavy gauge galvanized rails and further mounted on spring isolation devices.

E. Control panel / connections: unit shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections.

F. Indirect Gas-Fired Furnace

1. Shall be ETL Certified as a component of the unit.
2. Shall have an integral combustion gas blower.
3. Shall be ETL Certified for installation downstream of a cooling coil.
4. Shall have fault sensors to provide fault conditions to optional digital controller or building controls.
5. Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.
6. Heat exchanger shall have a 5 year extended warranty
7. Furnace control shall be single furnace, 8 stage.
8. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off or hinged door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.
9. Shall have solid state controls permitting stand-alone operation or control by building controllers.

G. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.

H. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices. P trap must be insulated and shall have electric heat tape for

freeze protection. The condensate can drip onto the roof. Provide a splash block under drain discharge.

I. Packaged DX: Unit shall be equipped with a Packaged DX system to include compressor(s), evaporator and condenser coil(s), condenser fans and all appurtenant controls as specified elsewhere in this section. The Packaged DX system is to be an integral module, incorporated into the unit. Stand-alone Packaged DX systems that are connected to the unit or systems that require hardware or equipment that is not integral to the unit are not acceptable].

J. Direct Expansion Cooling Coil (DX Coil): Coil shall be AHRI Certified and shall be (silver) soldered or brazed into the compressed refrigerant system. Coil shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame. DX coil shall be optimized for refrigerant type: R-410A.

K. Motorized dampers / Intake Air: Motorized damper of low leakage type shall be factory installed.

L. Curb Assembly: A curb assembly shall be provided by the factory for assembly and installation as part of this division. The curb assembly shall provide perimeter support of the entire unit and shall have duct adapter(s) for supply air. Curb assembly shall enclose the underside of the unit and shall be sized to fit into a recess in the bottom of the unit. Contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly.

2.4 BLOWER

A. Blower section construction, Supply Air: Belt drive motor and blower shall be assembled onto a minimum 14 gauge galvanized steel platform and must have helical coil spring vibration isolation devices.

B. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

C. Centrifugal blower housing: Formed and reinforced steel panels to make curved scroll housing with shaped cutoff.

D. Forward curved blower (fan) wheels: Galvanized or aluminum construction with inlet flange and shallow blades curved forward in direction of airflow. Mechanically attached to shaft with set screws.

E. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, “Laboratory Methods of Testing Fans for Rating”.

2.5 MOTORS

A. General: Blower motors greater than ¾ horsepower shall be "NEMA Premium™" unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower and pulleys shall be fully machined cast-type, keyed and fully secured to the fan wheel and motor shafts. Electric motors of ten horsepower or less shall be supplied with an adjustable drive pulley. Comply with requirements in 23 05 13, matched with fan load.

2.6 UNIT CONTROLS

A. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management Control System (BMCS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors

B. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status, operating settings and alarm conditions. DDC controller shall have a built-in keypad to permit operator to access read-out screens and change settings without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.

1. Operating protocol: The DDC shall be factory-programmed for BACnet IP for monitoring of the unit's status. Coordinate with the BMCS contractor to verify exact requirements prior to ordering the unit.

C. Remote Interface: Contractor shall provide and install a Remote Interface that functions as a remote indicator of owner-selected operating parameters and also permits remote inputting of new operating parameters. Each remote panel shall have a large LCD user interface screen similar in form and function to the screen on the DDC. Installed location of room display shall be as indicated on the plans.

D. Sensors to be provided with the unit

1. Heating Inlet Air Sensor
2. Cooling Inlet Air Sensor
3. Dirty Filter Sensor
4. 120V/24V Smoke Detector

2.7 FILTERS

A. Unit shall have 2" thick MERV 13 disposable pleated filters located in the outdoor air intake and shall be accessible from the exterior of the unit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance. See unit IOM.

B. Examine roughing-in of plumbing, electrical and HVAC services to verify actual location and compliance with unit requirements. See unit IOM.

C. Proceed with installation only after all unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer's installation instructions as documented in manufacturer's IOM, Best Practices and all applicable building codes.

3.3 CONNECTIONS

A. In all cases, industry Best Practices shall be incorporated. Connections are to be made subject to the installation requirements shown above.

B. Piping installation requirements are specified in Division 22 (Plumbing). Drawings indicate general arrangement of piping, fittings and specialties.

C. Duct installation and connection requirements are specified in Division 23 of this document.

D. Electrical installation requirements are specified in Division 26 of this document.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to A/E in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM.

3.5 START-UP SERVICE

A. Engage a factory authorized service representative to perform startup service. Clean entire unit, comb coil fins as necessary, and install clean filters. Verify water source for compliance with manufacturer's requirements for flow and temperature. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.

3.6 DEMONSTRATION AND TRAINING

A. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Packaged, outdoor, evaporative-cooled, indirect, gas-fired heating, DX cooling, central-station air-handling units with the following components and accessories as a minimum:

1. Supply fan section.
2. Return fan section.
3. Evaporative-cooling components.
4. Refrigeration components.
5. Gas-fired heating section.
6. Unit operating controls.
7. Filter section(s).
8. Mixing section.
9. Dampers.
10. Airflow monitoring stations.
11. Single point power connection with unit disconnect, motor starters and variable frequency drives.
12. General lighting and convenience receptacles.
13. Roof Curbs.

B. All components and accessories are to be factory mounted and wired, unless otherwise noted.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 00 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 00 – Commissioning .

F. Section 07 72 00 - Roof Accessories.

G. Section 22 21 23 - Facility Natural-Gas Piping.

H. Section 23 05 00 - Common Work Results for HVAC.

I. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

J. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

K. Section 23 07 00 - HVAC Insulation.

L. Section 23 08 00 - Commissioning of HVAC.

M. Section 23 09 00 - Instrumentation & Control for HVAC.

N. Section 23 09 93 - Sequence of Operations for HVAC Controls.

O. Section 23 23 00 - Refrigerant Piping.

P. Section 23 41 00 - Particulate Air Filtration.

Q. Section 26 29 13 - Enclosed Controllers: Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

R. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1. Variable-frequency motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

1.4 REFERENCES

A. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

B. AHRI 360 - Unitary Air-Conditioning Equipment.

C. ANSI/ASHRAE/IESNA 90.1-1999 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.

D. California Administrative Code - Title 24 Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California.

1.5 DEFINITIONS

A. DDC: Direct digital control.

B. ECM: Electrically commutated motor.

C. RTU: Rooftop Air Handling unit. As used in this section, this abbreviation means outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.7 QUALITY

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

D. UL Compliance: Comply with UL 1995.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1. All unit mounted devices shall be at a height above the finished roof to assure access without the use of ladders by the owner's maintenance personnel.

F. Service for the unit shall be available locally either directly from the manufacturer or from the manufacturer's certified local representative.

G. The unit shall comply with the requirements of the Buy American Act and be defined as a domestic end product as per the two part test described therein.

H. Components not manufactured at the factory shall be provided by manufacturers regularly engaged in the production of such equipment and shall conform to recognized industry standards.

I. Units shall be built and shipped in one single piece or in separate modules, as required by the project specification and/or restrictions at the job site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Units shall be shipped with integral lifting lugs welded to the unit frame. Before leaving the factory, units shall be wrapped, packaged, and sufficiently protected for transportation by truck and outdoor storage. Duct connection openings shall be covered with plywood.

B. Unit should immediately be inspected for any damage that may have occurred during shipping. Care should be used whenever handling the unit to avoid damaging any components, wiring, or the unit surface finish.

C. Although the unit packaging is weather resistant, if the unit is not to be immediately installed, it should be stored in a dry place protected from weather, traffic, and unauthorized personnel.

D. If the unit is to be stored for any length of time, it must be supported and cribbed along the full length of its support channel. Major support should be provided at the perimeter of the unit and at the furnace section. The unit can rest on the angle iron perimeter frame, but should not be supported where there is no framing underneath.

E. If the unit is not immediately installed and run, the blower bearings should be regreased and wrapped with plastic. After each month of storage the bearings should be purged with new grease to remove any accumulated moisture.

F. If the blowers are not regularly run, the blower wheels should be manually rotated every two weeks to redistribute the grease and prevent flat spots from developing on the bearings.

1.9 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include manufacturer's technical data for each AHU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

C. Sustainable Design Submittals:

1. Product Data: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

E. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

J. Warranty: Special warranty specified in this section.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fails in materials and installation for two years, except as otherwise noted below, from substantial completion.

1. Control Boards: Three (3) years.
2. Compressors: Ten (10) year extended warranty.
3. Gas-fired heat exchanger: Ten (10) year limited warranty.

1.11 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One (1) set for each belt-driven fan.
2. Filters: One (1) set of filters of each filter type for each unit.

PART 2 - PART 2 PRODUCTS

2.1 MANUFACTURERS

A. GENERAL

1. Manufacturer of packaged unitary rooftop products shall have had a minimum of five years successful experience in the manufacture and service support of the

rooftop packages specified herein. Manufacturers with less than five years experience in the production of rooftop units of the sizes and types specified shall not be acceptable.

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Trane: Model – SFHL Series (Basis of Design)
2. McQuay: Model - RoofPak Series
3. AAON: Model - RL Series
4. Substitutions: No substitutions

2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be evaporative condenser packaged rooftops as specified on the contract documents and within these specifications. Cooling capacity ratings shall be based upon AHRI Standard 360. Unit(s) shall consist of insulated weathertight casing with compressors, evaporative cooled condenser coil, condenser fans, evaporator coil, filters, supply and/or exhaust fan motors and drives, and packaged unit controls

B. Unit(s) shall be single piece construction as manufactured at the factory. Site assembled sub- assemblies will not be allowed. Package units shall be constructed for installation on a roof curb providing full perimeter support under air handler section and pedestal support under condenser section.

C. Unit(s) shall be factory run tested to include the operation of all fans, compressors, heat exchangers, and control sequences.

D. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

2.3 UNIT CASING

A. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating durable enough to withstand a minimum of 500 consecutive-hour salt spray application in accordance with standard ASTM B 117. Structural members shall be heavy gauge with access doors and removable panels of heavy gauge steel. Roof panels shall be sloped to provide positive drainage of rain water / melting snow away from the cabinet.

B. Provide custom exterior paint colors to meet Architect/Owners specification.

C. Access Doors: Fully gasketed hinged doors with fluted knob fasteners and chained "tie-backs" to provide access to filters, heating section, return/exhaust air fan section, supply air fan section and evaporator coil section.

D. Control Panel: The unit control panel section shall be compartmented to separate high and low voltage components. The control panels shall also be fully gasketed, hinged and provided with quick release latches for easy access.

1. The high voltage control panel shall be provided with a door handle disconnect switch to facilitate convenient, safe disconnection of main three phase power.

E. Insulation: Provide 1/2 inch thick coated fiberglass internal liner on all exterior panels in contact with the conditioned air stream.

2.4 FANS

A. Mount fan motor(s) and fan on a common base assembly and isolated from unit with spring isolators. Provide thrust restraint isolation on the fan housing/fan board to assure smooth fan startup transition and operation.

B. Fan shaft shall be mounted on grease lubricated ball bearings with extended grease lines.

C. Motor shall be open drip proof. Motor shall have a standard T-frame and a minimum service factor of 1.15. All drive components shall be accessible without the use of scaffolds or ladders, to facilitate periodic maintenance checks and for operator safety.

D. Internal Shaft Grounding Ring, Motors have internal bearing protection for use with VFDs to provide a conductive discharge path away from the motor bearings to ground. Bearing Protection Rings are circumferential rings with conductive micro fibers which provide the path of least resistance and dramatically extend motor life.

E. SUPPLY

1. Supply fans shall have two double-inlet, forward-curved fans mounted on a common shaft with fixed sheave drive. Fans shall be factory-tested to reach rated rpm before the fan shaft passes through first critical speed. Fan shaft shall be mounted on two grease lubricated ball bearings designed for 200,000 hours average life. Extended grease lines shall allow greasing of bearings from unit filter section. Fan motor and fan assembly shall be mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. Entire assembly shall be completely isolated from unit and fan board by 2" deflection spring isolation.

F. EXHAUST/RETURN FANS

1. Provide forward curved exhaust fans with fixed-pitch sheave drive assemblies. Dynamically balance all fans and the unit's running fan assembly (fan mounted on actual shaft, bearings and in scroll housing) to assure smooth operation of the fan and its associated assembly. Balancing of the fan only shall not be acceptable.

2.5 GAS FIRED HEATING SECTION

A. Provide gas-fired heating section as a completely assembled and factory-installed heating system integral to unit, cULus approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Provide capability for threaded gas piping connection through side or bottom of unit.

B. Heating section shall be factory fire-tested prior to shipment.

C. Gas Burner: Forced-draft type burner with adjustable combustion air supply, gas valve, manual shut-off, direct spark or pilot ignition, and flame sensing monitoring electrode. Provide air proving switch to prevent burner operation when burner is open for maintenance or inspection.

D. Gas Burner Safety Controls: Provide electronic flame safety controls for the proving of combustion air prior to ignition sequence with pre-purge cycle, continuous electronic flame supervision, and sixty second delay between first and second stage gas valve operation on two-stage heaters.

E. Combustion Blower: Provide centrifugal type fan with built-in thermal overload protection on fan motor.

F. Heat Exchanger: Provide factory pressure- and leak-tested tubular two pass heat exchanger of free-floating design manufactured of 16-gauge stainless steel primary surface and 18-gauge stainless steel secondary surface.

G. Gas heaters shall be constructed of grades of stainless steel suitable for condensing environments. The heater shall provide <<MODULATION_TYPE3>> and contain a modulating gas valve that responds to user selectable setpoints.

2.6 EVAPORATOR COIL SECTION

A. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Evaporator coil shall be inter- circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency.

B. Provide a thermostatic expansion valve (TXV) for each refrigerant circuit. Factory pressure and leak test coil.

C. Provide pitched stainless steel drain pan to assure positive drainage of condensate from the unit casing.

2.7 EVAPORATIVE CONDENSER SECTION

A. Minimal maintenance sump pump shall be fully accessible through the evaporative-condenser access panel. Water is pumped at a minimum 50 GPM. The pump shall be powered by 460V/3-phase.

B. The condenser fans for the evaporative condenser shall be variable speed and are modulated based on head pressure control which is determined by the unit controls.

C. The water basin, corner posts and roof for the evaporative condenser housing shall be constructed with 304 Stainless Steel. Water basin shall be lined with FRP coating to make it watertight. The side panels and sliding access doors shall be constructed of corrosion and UV resistant, low density fiberglass. Housing shall also have 4 lifting holes, one in each corner to handle the unit with crane.

D. Evaporative Condensing-Coils shall be durable copper 5/16" OD, 0.022 wall thickness serpentine tubing that shall provide strength and resilience for expansion.

E. Water level in the Evaporative Condensing-Sump shall be maintained by a mechanical fill valve that is adjusted to a predetermined point. The sump shall consist of two float switches to ensure proper water levels are being maintained. The minimum level float switch shall protect the sump pump from running dry by de-energizing all stages of mechanical cooling and the sump pump, if the water ever drops below the minimum level. The sump heater will also be de-energized in low water level conditions. The maximum level float switch shall prevent the overfilling of the sump and water wastage by de-energizing the fill valve when a predefined maximum level is reached in the sump. The level switches shall be permanently affixed to the water basin and shall not require any field adjustment.

F. Water Treatment: To simplify field installation of water treatment, unit shall have hookups for water treatment devices. A water conductivity controller shall be provided. Water treatment is required for all evaporative condenser units to ensure proper equipment life, product performance and operation. Provide a complete condenser water treatment system as manufactured by Dolphin Water Care. All treatment components, unless specifically suited for exterior applications, shall be located internal to the RTU. MC to coordinate with the RTU and water treatment manufacturers to provide a complete working treatment system in accordance with the RTU manufacturers requirements for water quality. All treatment equipment shall be factory mounted, piped, wired, and tested. Controls shall be in accordance with the RTU manuf. requirements.

2.8 REFRIGERATION SYSTEM

A. Compressor: shall be industrial grade, energy efficient direct drive 3600 RPM maximum speed scroll type compressor. The motor shall be of a suction gas cooled hermetic design. Compressor shall have centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve. Motor protection is provided by either a patented motor cap and integral line break motor protector or an external 24 VAC module which provides protection against incorrect phase sequence, excess motor temperatures, over current protection, and phase loss. In addition, each compressor have a crankcase heater installed, properly size to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

B. Provide with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge. Provide high and low-pressure cutouts and reset relay.

C. Provide factory-installed compressor lockout thermostat to prevent compressor operation at low ambient conditions.

D. Provide coil frost protection compressor unloading based on refrigerant circuit suction temperature to prevent coil frosting with minimum energy usage. As an alternate, factory-installed hot gas bypass shall be required on all VAV units to prevent coil frosting.

E. Phase and Voltage Monitor - Standard on 20-75 ton air-cooled units. Protects 3-phase equipment from phase loss, phase reversal and low voltage. Any fault condition will produce a Failure Indicator LED and send the unit into an auto stop condition. cULus approved.

F. Modulating Hot Gas Reheat - Hot gas reheat shall consist of the following refrigeration components on one circuit: a hot gas reheat coil, a cooling modulating valve, a reheat modulating valve, a reheat check valve, a reheat pump out solenoid, and additional interconnecting tubing.

2.9 EXHAUST/RETURN SECTION

A. 100 Percent Modulating Return Fan shall be mounted on a shaft with fixed sheave drive. The fan shall be dynamically balanced for the operating envelop and tested in factory before being installed in unit. The fan shall be test run in unit as part of unit test. Fan operating envelop rpm shall be below first critical speed. Fan shaft shall be mounted on two grease lubricated ball or roller bearings designed for 200,000-hour average life. Extended grease lines shall be provided to allow greasing of bearings from section base rail. Fan motor and assembly shall be mounted on common base to allow consistent belt tension with no relative motion between fan and motor shafts. The entire assembly shall be completely isolated from unit with 2-inch spring isolators.

Discharge dampers at unit outlet shall modulate relief airflow in response to OA / return air damper position. The return fan VFD shall operate in conjunction with the supply fan.

2.10 OUTDOOR AIR SECTION

A. Provide 100% modulating enthalpy-based economizer system fully integrated with unit return and exhaust air dampers. Unit operation is through primary temperature controls that automatically modulate dampers to maintain desired space temperature conditions.

1. Provide automatic outdoor enthalpy lockout sensor.

B. Provide adjustable minimum position control through the unit controller via the BAS.

C. Provide spring-return motor for outside air damper closure during unit shutdown or power interruption.

D. Economizer Control with Comparative Enthalpy - Used with the outside air economizer, two enthalpy sensors are provided to compare total heat content of the indoor air and outdoor air to determine the most efficient air source when economizing.

2.11 DAMPERS

A. Provide low leak dampers as standard with a leakage rate of 2.5 percent of nominal air flow (400 CFM/Ton) at 1 inch wg. Static pressure.

B. Leakage rate shall be determined in accordance with AMCA Standard 500 and 575.

2.12 FILTERS

A. Differential Pressure Gauge - A factory-installed, dial-type, differential pressure gauge shall be piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Gauge shall be flush-mounted with casing outer wall. Filter sections consisting of pre- and post-filters shall have a gauge for each.

B. 90-95% Cartridge Filter, MERV 14 —Twelve-inch deep cartridge filters shall be mounted in a galvanized steel frame. Filters shall be Class 1 listed by Underwriters Laboratories and have a 90-95% dust spot efficiency per ASHRAE 52-76.To ensure maximum cartridge filter life, two-inch MERV 8 prefilters shall be provided.

2.13 DDC MICROPROCESSOR CONTROLS

A. General - Each unit shall be provided with a factory-installed, programmed and run-tested, stand-alone, microprocessor control system suitable for VAV control. This system shall consist of temperature and pressure (thermistor and transducer) sensors, printed circuit boards, and a unit-mounted Human Interface Panel. The microprocessor shall be equipped with on-board diagnostics to indicate that all hardware, software, and all interconnected wiring and sensors are in proper operating condition. The microprocessor's memory shall be non-volatile EEPROM type, thus requiring no battery or capacitive backup to maintain all data during a power loss.

B. The Human Interface Panel shall be readily accessible for service diagnosis and programming without having to open the main control panel on the rooftop unit. Alphanumeric coded displays shall not be acceptable.

1. Human Interface (HI) Panel - shall be a 16 key touch-sensitive membrane key switch panel, password protected to prevent use by unauthorized personnel. The Human Interface Panel display shall consist of a 2 line by 40 characters per line clear english display. The display shall be Supertwist Liquid Crystal Display (LCD) with blue characters, 5 X 7 dot matrix with cursor, on a gray-green background for high visibility and reading ease.

C. Remote Human Interface (RHI) - shall provide the same diagnostic monitoring and control capabilities as the unit mounted Human Interface Panel (except, for service technician safety, the "service test mode") including clear English display. The Remote Human Interface shall be capable of controlling up to four rooftops simultaneously. The Remote Human Interface device shall function in conjunction with the unit mounted Human Interface Panel. Removal of the unit mounted Human Interface, for remote mounting, while leaving no interface at the rooftop unit, shall not be permitted. Night setback and morning warmup functions shall also be established through the RHI, as well as the HI, as desired by the user.

D. BACnet communication interface module – provides for full control and monitoring of the RTU by the Owner’s existing BMCS utilizing BACnet control.

E. Airflow modulation shall be provided by a variable frequency drive with bypass that is factory-mounted, completely wired, and functionally tested. Adjustable frequency inverter drive shall safely vary the speed of the fan motor allowing the motor to meet the dynamic requirements at the shaft of the motor and meet the system static. Properly sized motor protection shall be provided in both drive and bypass modes by a motor overload relay and fuses. Inverter controller shall have a display that provides readout functions that include: output frequency, output voltage, output current, output power, DC bus voltage, interface terminal status, and fault status. In the bypass mode, an output signal shall be available for a building automation system to make system adjustments to prepare for an across the line start of a fully loaded fan. A run command signal to the bypass motor starter shall be provided by the unit controller.

1. Internal Shaft Grounding Ring - Motors have internal bearing protection for use with VFDs.

PART 3 - EXECUTION

3.1 SHIPPING

A. Paper copies of the IOM shall also be shipped with each RTU.

B. The AHU Manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU Manufacturer shall place them in containers.

C. To protect equipment during shipment and delivery, all outdoor units shall be completely shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.

D. After loading the equipment for shipment, the RTU Manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

3.2 ON-SITE STORAGE

A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

3.3 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 LEVELING

A. The Mechanical Contractor shall laser level all unit mounting surfaces, including housekeeping pads, roof curbs, and/or structural steel prior to rigging and installation of the RTU units. Should the RTU units be installed on an unlevel surface, the Mechanical Contractor shall rework the installation at his/her own expense and to the satisfaction of the Owner and Engineer and to ensure proper installation.

3.5 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 07 72 00. Secure RTUs to upper curb rail, and secure curb base to roof framing.

B. Unit Support (Where indicated): Install unit level on structural platform, curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23 05 48.

D. The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or -welded joints, and all other installation and assembly requirements.

E. The RTU Manufacturer shall provide all screws and gaskets for joining of sections in the field.

F. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the RTU Manufacturer's final inspection and start-up:

1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
3. All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
4. All gas piping connections have been completed and tested.

5. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
6. All power wiring, including motor starters and disconnects, serving the unit has been completed.
7. All automatic temperature and safety controls have been completed.
8. All dampers are fully operational.
9. All shipping materials have been removed.
10. All (clean) filter media has been installed in the units.

3.6 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTU coils to allow service and maintenance.

C. Duct installation requirements are specified in other Division 23 sections. Drawings indicate the general arrangement of ducts.

1. Connect supply ducts to RTUs with flexible duct connectors specified in Section 23 33 00.
2. Where ductwork is connected to unit bottom connections (see drawings for unit connections), the following are specific connection requirements:

    a. Install ducts to termination at top of roof curb.
    b. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
    c. Install ducts continuously through roof structure.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections:

1. After installing AHUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Remove packing from vibration isolators.
9. Verify lubrication on fan and motor bearings.
10. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
11. Adjust fan belts to proper alignment and tension.
12. Start unit according to manufacturer's written instructions.
    a. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for an initial period as recommended or required by manufacturer.
15. Calibrate thermostats.
16. Adjust and inspect high-temperature limits.
17. Inspect dampers for proper stroke.
18. Start system and measure and record the following:
    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
20. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve. Replace fan and motor pulleys, and sheaves as required to achieve design conditions.
    a. Supply-air volume.

b. Return-air volume.
c. Relief/exhaust-air volume.
d. Outdoor-air intake volume.

21. Verify operation of operation and failure modes. Inspect the following:

a. Low-temperature safety operation.
b. Filter high-pressure differential alarm.
c. Economizer to minimum outdoor-air changeover.
d. Relief-air fan operation.
e. Smoke and/or firestat alarms.

22. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests in accordance with Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer’s written instructions/requirements.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 40 hours to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Packaged, outdoor, indirect, gas-fired heating, DX cooling, flat plate HX, central-station air-handling units with the following components and accessories as a minimum:

1. Supply-air fan section.
2. Flat plate heat exchanger.
3. Refrigeration components.
4. Gas-fired heating section.
5. Unit operating controls.
6. Filter section(s).
7. Mixing section.
8. Dampers.
9. Airflow monitoring stations.
10. Single point power connection with unit disconnect, motor starters and variable frequency drives.
11. General lighting and convenience receptacles.
12. Roof Curbs.

B. All components and accessories are to be factory mounted and wired, unless otherwise noted.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 00 - Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 91 00 – Commissioning .

F. Section 07 72 00 - Roof Accessories.

G. Section 22 21 23 - Facility Natural-Gas Piping.

H. Section 23 05 00 - Common Work Results for HVAC.

I. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

J. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

K. Section 23 07 00 - HVAC Insulation.

L. Section 23 08 00 - Commissioning of HVAC.

M. Section 23 09 00 - Instrumentation & Control for HVAC.

N. Section 23 09 93 - Sequence of Operations for HVAC Controls.

O. Section 23 23 00 - Refrigerant Piping.

P. Section 23 41 00 - Particulate Air Filtration.

Q. Section 26 29 13 - Enclosed Controllers: Motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

R. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1. Variable-frequency motor controllers are to be supplied by the mechanical contractor and installed by the electrical contractor.

1.4 REFERENCES

A. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

B. ASTM E1332 - Standard Classification for Determination of Outdoor-Indoor Transmission Class

C. SMACNA - HVAC Duct Construction Standards—Metal and Flexible

D. ARI 1060 - Rating Air-To-Air Energy Recovery Ventilation Heat Exchangers

E. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes [Remove if not using AMCA rated fans]

F. NEMA MG1 - Motors and Generators

G. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings

H. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils

I. UL 1995 - Heating and Cooling Equipment

J. ANSI Z83.8 - Standard for Gas Unit Heaters and Gas-Fired Duct Furnaces

K. ASTM A-249 - Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat- Exchanger, and Condenser Tubes (for Gas Unit Heaters and Gas-Fired Duct Furnaces)

L. ASHRAE 52-76 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI/ASHRAE Approved) (for Filters)

M. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality

1.5 DEFINITIONS

A. DDC: Direct digital control.

B. ECM: Electrically commutated motor.

C. RTU: Rooftop Air Handling unit. As used in this section, this abbreviation means outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.7 QUALITY

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

D. UL Compliance: Comply with UL 1995.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1. All unit mounted devices shall be at a height above the finished roof to assure access without the use of ladders by the owner's maintenance personnel.

F. Service for the unit shall be available locally either directly from the manufacturer or from the manufacturer's certified local representative.

G. The unit shall comply with the requirements of the Buy American Act and be defined as a domestic end product as per the two part test described therein.

H. Components not manufactured at the factory shall be provided by manufacturers regularly engaged in the production of such equipment and shall conform to recognized industry standards.

I. Units shall be built and shipped in one single piece or in separate modules, as required by the project specification and/or restrictions at the job site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Units shall be shipped with integral lifting lugs welded to the unit frame. Before leaving the factory, units shall be wrapped, packaged, and sufficiently protected for transportation by truck and outdoor storage. Duct connection openings shall be covered with plywood.

B. Unit should immediately be inspected for any damage that may have occurred during shipping. Care should be used whenever handling the unit to avoid damaging any components, wiring, or the unit surface finish.

C. Although the unit packaging is weather resistant, if the unit is not to be immediately installed, it should be stored in a dry place protected from weather, traffic, and unauthorized personnel.

D. If the unit is to be stored for any length of time, it must be supported and cribbed along the full length of its support channel. Major support should be provided at the perimeter of the unit and at the furnace section. The unit can rest on the angle iron perimeter frame but should not be supported where there is no framing underneath.

E. If the unit is not immediately installed and run, the blower bearings should be regreased and wrapped with plastic. After each month of storage, the bearings should be purged with new grease to remove any accumulated moisture.

F. If the blowers are not regularly run, the blower wheels should be manually rotated every two weeks to redistribute the grease and prevent flat spots from developing on the bearings.

1.9 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

C. Sustainable Design Submittals:

1. Product Data: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

E. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" article and in Section 23 05 48.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings
3. Roof curbs and flashing.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

J. Warranty: Special warranty specified in this section.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fails in materials and installation for two years, except as otherwise noted below, from substantial completion.

1. Control Boards: Three (3) years.
2. Compressors: Ten (10) year extended warranty.
3. Gas-fired heat exchanger: Ten (10) year limited warranty.

1.11 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One (1) set for each belt-driven fan.
2. Filters: One (1) set of filters of each filter type for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Only manufacturers that specialize in the production of energy recovery equipment and/or the other type of equipment specified herein, have a minimum of ten (10) years of experience, and who have published a complete catalog with performance data are approved to provide the specified equipment for this project.

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. XeteX, Inc. (Basis-of-Design)
2. Trane Custom Air Handler
3. Mammoth
4. Substitutions: No substitutions

2.2 GENERAL UNIT DESCRIPTION

A. Contractor shall provide a roof mounted 100% outside air custom unit with a gas fired heat exchanger with packaged DX cooling and an air to air aluminum fixed plate heat exchanger capable of pre-cooling OA and re-heating cooled air from the DX coil, to provide cooled dehumidified air to the space. Adjustable frost control and specified options as noted herein and on drawings.

2.3 UNIT CASING

A. Welded Structural Steel Base Frame and Floor:

1. Unit shall have an all-welded base frame constructed from structural steel. The frame shall include formed supports constructed from welded structural steel under blowers and other components.
2. The base frame shall incorporate a minimum of four (4) integral lifting lugs for every separate unit section.
3. A 16-gauge galvanized steel interior floor shall be installed on the base frame. Openings in the floor shall be covered with a protective grate. The floor shall be insulated and a 22-gauge galvanized steel sub-floor shall be installed under the insulation.
4. Floor insulation shall be 2” thick and consist of a load-bearing, rigid, closed-cell polyiso foam core laminated to a black glass reinforced mat facer. Insulation blowing agents shall be HCFC-free and qualify under the Federal Procurement Regulation for Recycled Material. Additionally, insulation shall meet the following criteria:

a. Insulation shall have an LTTR R-Value of 12.1 (where the LTTR is based on a 15 year time-weighted average in accordance with CAN/ULC-S770).
b. Insulation shall have a compressive strength of 20 psi under ASTM D 1621, a density of 2 pcf under ASTM D 1622, a dimensional stability of less than 2% under ASTM D 2126, a moisture vapor transmission of less than 1 Perm under ASTM E 96, and a water absorption of less than 1% by volume under ASTM C 209. Insulation shall have a service temperature of –100 °F to 250 °F.
c. Insulation shall be compliant with the following specifications: ASTM C1289, Type II, Class 1; UL Classified; FM Class 1 Approved; and CAN/ULC-S704. Additionally, the manufacturer's facility shall be ISO 9002 Registered.

5. All seams in the base frame shall be sealed and the frame shall be coated with a rust inhibiting paint. The perimeter of the frame shall be insulated.

B. Drain Pans:

1. Drain pans shall be provided in all cooling coil (stainless steel), and heat exchanger sections (galvanized) where condensate might be present.
2. Drain pans shall be double sloped, have all welded seams, MPT connections, and be constructed from 304 stainless steel. Drain pans with a bitumastic coating are not acceptable because of their poor durability.
3. Flat Plate Heat Exchanger section shall have two separate, full width, double sloped drain pans, one in the supply air plenum and one in the exhaust air plenum. Each drain pan shall be 3" deep minimum with its own MPT drain. The heat exchanger shall be removable from the unit without requiring that the drain pans be removed, deconstructed, split, or damaged in any way. Exchanger sections with one drain pan or two single-sloped drain pans are not acceptable. Configurations that require the drain pans to be removed, deconstructed, split, or damaged in any way in order to remove the exchanger are not acceptable.
4. Cooling coil sections will have 304 stainless steel] drain pans, double sloped with MPT connections.
5. For indoor units, all drain connections shall terminate on the sides of the unit. For Outdoor units, drain connections shall terminate either on the sides of the unit or on the bottom of the unit.

C. Hinged Access Doors:

1. Access to all exchanger surfaces, blowers, motors, filters, and other components requiring regular maintenance shall be provided through access doors.
2. Access doors shall have double-wall construction with 18 gauge (minimum) galvanized steel inner and outer walls and 3# density hardboard fiberglass insulation. Doors shall have an 11" x 11" double pane safety glass viewing window. Access door construction shall be otherwise consistent with the unit panel and frame.

3. Access doors shall be held closed by a minimum of two roller cam latches. Door hinges shall be galvanized steel steel. Doors shall be removable from the unit frame.
4. Access door frames shall be made from galvanized steel. Continuous hollow rubber gasket shall be applied to all access openings to provide water and airtight seals.
5. Doors shall come equipped with hook-and-keeper holders to keep doors open against the side of the unit. Holders shall be zinc-plated and incorporate spring-loaded keepers to prevent unintentional door release.

D. Acoustical Performance:

1. The acoustical performance of cabinet panels shall be tested by an accredited independent laboratory under the ASTM E90 and E1332 standards and have a certified STC rating of 39 for 2" walls and an OITC rating of 27 for 2" walls.
2. Sound absorption data is not an acceptable substitute for OITC rating data. Manufacturer shall provide a testing report from the accredited independent laboratory and Transmission Loss data upon request.
3. Acoustical performance shall be as per the scheduled on the drawings.

E. Double Wall Construction:

1. Cabinet frame exterior shall be of formed 18 gauge (minimum) galvanized steel. Panels (fixed and access) to be of 18-gauge galvanized steel.
2. Frame and panels to be double-walled construction with two-inch-thick insulation and shall of a load-bearing, rigid, closed-cell polyiso foam core laminated to a black glass reinforced mat facer. Insulation blowing agents shall be HCFC-free and qualify under the Federal Procurement Regulation for Recycled Material. Additionally, insulation shall meet the following criteria:

    a. Insulation shall have an LTTR R-Value of 12.1 (where the LTTR is based on a 15-year time-weighted average in accordance with CAN/ULC-S770).
    b. Insulation shall have a compressive strength of 20 psi under ASTM D 1621, a density of 2 pcf under ASTM D 1622, a dimensional stability of less than 2% under ASTM D 2126, a moisture vapor transmission of less than 1 Perm under ASTM E 96, and a water absorption of less than 1% by volume under ASTM C 209. Insulation shall have a service temperature of –100 °F to 250 °F.
    c. Insulation shall be compliant with the following specifications: ASTM C1289, Type II, Class 1; UL Classified; FM Class 1 Approved; and CAN/ULC-S704. Additionally, the manufacturer's facility shall be ISO 9002 Registered.
    d. Frame and panels to have an internal liner of 22 gauge (minimum) galvanized steel – Optional aluminum and be sealed with silicone sealant to provide complete vapor barrier and non-containing surface to all air streams.

3. Framing and panels of dissimilar metals that could create a galvanic effect are not allowed.

F. Unit Finish:

1. Unit exterior shall be constructed from Galvanealed Steel and primed with industrial Pro-Cryl® universal primer. Primer shall be a single component cross-linking acrylic and designed for construction applications. It shall further be VOC compliant, rust inhibitive, and early moisture and corrosion resistant.
2. Primer shall be applied to a thickness of 5.0 – 10.0 wet mils / 2.0 – 4.0 dry mills.
3. A top coat of Sher-Cryl® HPA high performance acrylic shall be painted over the primer. The top coat shall be an ambient cured, one component acrylic coating. It shall be chemical, flash and rust, and corrosion resistant.
4. The top coat shall be applied to a thickness of 6.0 – 10.0 wet mils / 2.5 – 4.0 dry mills.
5. The exterior finish shall meet the following performance requirements:

Test:	Adhesion	Corrosion Weathering	Direct Impact Resistance	Dry Heat Resistance
Method:	ASTM D4541	ASTM D5894, 10 Cycles, 3360 hours	ASTM D2794	ASTM D2485
Result:	500 psi	Pass	>140 in. lbs.	200 °F

Flexibility	Moisture Condensation Resistance	Pencil Hardness	Salt Fog Resistance
ASTM D522, 180° bend, 1/4" mandrel	ASTM D4585, 100° F, 1250 hours	ASTM D3363	ASTM B117, 1250 hours
Pass	Pass	H	Pass

6. Exterior finish shall provide performance comparable to products formulated to federal specification AA50570/AA50557 and paint specification SSPC-Paint 23.
7. Unit interior finish shall be G90 Galvanized steel.

2.4 Air-to-Air Flat Plate Heat Exchanger

A. Aluminum Exchanger: Air-to-air heat exchanger shall be an XLT stationary aluminum flat plate type manufactured by XeteX. Heat transfer surface shall be formed aluminum plates with enhanced surface corrugation for increased performance. Exchanger shall be capable of withstanding a pressure difference between airflows of up to 7.2" w.c. (for model H), or 16” w.c. (for model P) without deforming air passages. Unit shall be capable of operating in temperatures up to 190 °F. Standard cell construction shall have a maximum cross contamination between airflows of 0.01% of total airflow. The entire cell shall be capable of being visibly inspected and cleaned as required.

2.5 Blowers, Motors, and Mounts

A. Blowers shall be:

B. Forward Curved—class I, forward curved, DWDI or SWSI, and arranged in a draw through configuration relative to exchanger for quiet and efficient operation;

C. Backward Inclined— class I or II, non-overloading, backward inclined, centrifugal plenum type with airfoil blades and no scroll housings and arranged in a draw-through configuration relative to the exchanger for quiet and efficient operation.

D. Blowers shall incorporate a wheel; heavy gauge reinforced steel inlet plate shaft, and bearings configured in AMCA Arrangement 3 to form a heavy-duty integral unit. Blowers shall be tested to AMCA standard 210 and bear the AMCA certified ratings seal for performance.

E. The fan blades shall be continuously welded, die-formed airfoil type, designed for maximum efficiency and quiet operation. Impellers shall be statically and dynamically balanced and non-overloading. Complete fan assembly shall be test balanced at the operating speed prior to shipment.

F. Bearings are to be heavy duty, grease lubricated, and selected for minimum average bearing L–50 life of 200,000 at the maximum class RPM.

G. Direct drive motors shall be efficiency, multi-speed, PSC type with internal thermal overload protection.

H. Belt drive motors shall be premium efficiency, NEMA frame, ODP—optional TEFC or XP, nominal 1,750 rpm, 1.15 service factor minimum, and mounted on an adjustable base. Motors and blowers shall have V-belt drives with variable pitch sheaves (on motors up to 10 hp) or fixed sheaves (on motors above 10 hp). Belt drive fans shall have a hollow rubber gasket around the fan discharge to provide an airtight seal while allowing for easy removal and replacement of the fan without screws or permanent fasteners. The discharge gasket shall isolate the fan from the unit casing and eliminate the requirement for an expansion duct fitting.

I. Motor and blower are to be mounted on a common frame, isolated from the unit case with RIS isolators—optional spring isolators with a minimum of 1” deflection or seismic isolators and flexible duct plenum connections.

J. Motors, blowers, and frames shall be coated with rust inhibiting paint—optional epoxy or Heresite coated.

K. Backward Inclined (BI) Single Width Single Inlet (SWSI), Air Foil (AF) Plenum Blower

L. Supply and Exhaust air blowers shall be a backward inclined airfoil centrifugal plenum type without scroll housing arranged in a draw-through configuration. Fans shall incorporate a wheel; heavy gauge reinforced steel inlet plate shaft, and bearings in AMCA Arrangement 3 configuration to form a heavy-duty integral unit. Blowers shall be tested to AMCA standard 210 and bear the AMCA certified ratings seal for performance.

M. The fan blades shall continuously welded, die-formed airfoil type, designed for maximum efficiency and quiet operation. Impellers shall be statically and dynamically

balanced, non-overloading, and complete fan assembly shall be test balanced at the operating speed prior to shipment.

N. Shafts are to be sized for first critical speed of at least 120% the maximum speed for the class.

O. Bearings are to be heavy duty; grease lubricated and selected for minimum average bearing L-50 life of 200,000 hours at the maximum class rpm.

P. Fan motors shall be premium efficient, ODP—optional TEFC, T-frame, 1750 rpm nominal with minimum service factor of 1.15 mounted on an adjustable base.

Q. Motor and blower are to be mounted on common frame and isolated from unit case with spring isolators with a minimum of 1" deflection—optional RIS, restrained, or seismic with flexible duct connections.

R. Motors and blowers shall have direct—or—V-belt drives with variable pitch sheaves on motors up to 10 hp.

S. Motors, blowers, and frames shall be coated with rust inhibiting paint—optional epoxy coated.

2.6 COILS: The following coils shall be provided.

A. DX Coil: DX Coil—Coils shall be circuited in a counter-flow manner to provide the maximum mean effective temperature difference for maximum heat transfer rates. Complete coil core shall be tested with 315 pounds air pressure under warm water and guaranteed for 250 psig working pressures. Coils shall be dehydrated with 140 °F DB, 40 °F dew-point air before shipment. Hydrostatic tests alone will not be acceptable. Coils shall be ARI certified and UL listed. Unit shall have welded stainless steel drain pans under DX coils and dehumidification section that are sloped to provide positive drainage.

2.7 HEATERS: Gas-Fired, Indirect—Drum and Tube Heat Exchangers

A. Heat exchangers shall be constructed and tested to the appropriate ANSI standards for efficiency and safe performance. Burners shall be ETL and UL Certified for electrical safety in compliance with UL 1995 safety standard for heating, ventilating and cooling equipment. The complete heat exchanger/burner assembly shall bear an active and current E.T.L. label as having been E.T.L. approved using Z83.8 standards.

B. The heat exchanger construction will be of 16-gauge minimum thickness 304 stainless steel secondary tubes, formed and stamped with the ASTM A-249 certification for heat exchanger application. The collection boxes and headers shall be constructed of 14

gauge minimum 304 stainless steel sheet. The flue collector is to be of type 304 stainless steel construction.

C. The heat exchanger shall have strategically located 304 stainless steel drains. The unit shall be mounted on rails of 14-gauge minimum G90 material, to assure airflow under the exchanger. Integral to the design of the base will be accommodation for the heat exchanger to expand and contract without damage to any part of the assembly.

D. All tubes in the last pass of the heat exchanger design shall have controlled dimples to maximize heat transfer and condensate drainage. No inserted turbulators or baffling will be allowed.

E. A front shroud constructed of 18-gauge minimum G90 will be provided to accommodate the air handler transitional ductwork.

F. 2" thick insulation, rated to 1000 °F shall be permanently attached to the shroud which will encase the insulation on all sides.

G. A U.L. and F.M. listed air flow proving switch shall be piped and wired to the front shroud. It will include piping to the air stream, strategically located for proper air flow detection purposes. The air switch will be wired in conduit to the burner limit circuit.

H. A U.L. and F.M. listed manual reset high temperature limit control with adjustable set point shall be attached to the front shroud. The capillary tubing will be extended to a location that will best detect high temperatures. The sensing bulb shall be firmly mounted to a bracket within the air stream. The high limit shall be wired in conduit to the burner limit circuit.

I. Each drain shall be piped in 304 SS and terminate with a plugged fitting on the burner side of the supplied shroud. Care in design to assure proper trapping of the condensate is required.

J. All tubes shall be welded to the collector boxes. No swage fitting of tubes is allowed.

K. The heating section shall be designed so there is no requirement for a powered venter in standard rooftop applications.

L. Gas burners shall be completely packaged with a single electrical and piping connection. Firing mode to be [Off/On firing, High/Low firing with proven low-fire-start, Standard Full Modulation; 4:1, 10:1 Modulation, or 20:1 High Turn Down Modulation].

M. In addition, the burner(s) shall comply with FM (Factory Mutual) requirements and/or I.R.I. guidelines.

N. Burners shall be fitted with orifices suitable for higher elevations (over 2000 feet). The burner and exchanger shall be mounted together as a single heating module.

2.8 AIR COOLED CONDENSING UNIT

A. The condensing section shall be an integral part of the unit and include one or more sealed refrigerant circuits including a hermitic motor–compressor, thermal expansion valve, bypass valves, finned tube air-to-refrigerant heat exchanger, crank case heaters, filter driers, and service ports.

B. Compressors shall be high-efficient 'Copeland' scroll type for 410A refrigerant and mounted on neoprene vibration isolators.

C. Compressors shall be 'Copeland' Digital Scroll type for 410A refrigerant and mounted on neoprene vibration isolators. Compressor capacity shall be capable of modulation between 10 and 100% of full capacity to provide better dehumidification, reduce compressor cycling, and decrease the starting electrical load. The modulation shall be achieved by axially separating, and thus unloading the scroll members. This separation shall be effected by bypassing a controlled amount of discharge gas to the suction side through a solenoid valve thereby lowering the pressure in the modulating chamber. No pumping action shall be required to achieve the modulation.

D. Safety controls shall include an anti-short cycle timer and high and low refrigerant pressure switches for protection against loss of charge and extreme low temperature operation.

E. A hot gas bypass system shall be installed on the lead refrigeration circuit allowing the cooling capacity of this circuit to be controlled with full modulation.

F. All wiring and plumbing shall be completed at the factory so that the unit, as shipped, contains a complete refrigeration package.

G. An insulated sound cover shall be provided for each compressor to control compressor noise. The cover shall consist of a reinforced vinyl envelope containing a 1" thick batt or 2.0–2.7 lb. density fiberglass insulation. All open edges shall be sealed with a double stitch and Velcro brand hook and loop closures. Covers shall be recognized through UL 94 5V as a Component-Miscellaneous Refrigeration Equipment.

H. Condenser Fans:

1. Fans shall be propeller type with aluminum blades and painted steel hubs.
2. Fans shall be dynamically balanced, and factory run tested.
3. Motors to be heavy-duty, 3-phase, open drip proof, with built in overload protection and permanently lubricated bearings.
4. Fan guards shall be made of heavy gauge steel wire.

2.9 FILTERS

A. Differential Pressure Gauge - A factory-installed, dial-type, differential pressure gauge shall be piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Gauge shall be flush-mounted with casing outer wall. Filter sections consisting of pre- and post-filters shall have a gauge for each.

B. 90-95% Cartridge Filter, MERV 14 —Twelve-inch deep cartridge filters shall be mounted in a galvanized steel frame. Filters shall be Class 1 listed by Underwriters Laboratories and have a 90-95% dust spot efficiency per ASHRAE 52-76. to ensure maximum cartridge filter life, two-inch MERV 8 prefilters shall be provided.

2.10 DAMPERS

A. Dampers shall have heavy duty extruded aluminum frames and 4” extruded aluminum air-foil blades mounted on brass shafts and supported and inter-connected by nylon gears. Low leakage dampers shall have hollow rubber jamb seals built into both the blades and the frame.

B. The side casings shall enclose the gears with ABS plastic covers that also serve as seals in the closed position.

C. Outside Air Shut-Off Dampers: Outside air dampers shall be mounted on the inlet of the unit and operated by a spring return, direct-coupled on-off actuator with an end switch to be interlocked with the supply air motor relay. Dampers shall have parallel blades.

D. Face-and-Bypass Dampers: Face-and-bypass dampers shall be mounted flush to the face of the exchanger and operated by a spring return, direct-coupled, modulating proportional actuator. Dampers shall be interlocked so that when the face damper is open the bypass damper shall be closed. A common square brass shaft shall drive both sections with a single direct-coupled actuator. Dampers shall have opposed blades.

2.11 ELECTRICAL

A. Electrical controls shall include for direct drive units: motors with internal thermal protection and relays; for belt drive units: variable frequency drives or motor starters with overloads, fused branch circuit breakers, control transformer for low voltage controls, service switch, and terminal points/blocks all contained in a NEMA 3R, unit-mounted control panel.

B. A single main disconnect switch for single point power connection shall be provided. The disconnect switch shall be mounted through the access panel so that power will have to be shut-off before the access door can be opened.

C. The mechanical contractor shall coordinate a separate 115-V power feed to each RTU to serve the convenience outlets and the lighting. High voltage wiring shall be done through flexible conduit. This power shall be available when the RTU's main unit disconnect has been locked-out.

D. The motor power and branch circuits shall be protected by circuit breakers so replaceable fuses will not be necessary.

E. All provided wiring and controls shall be factory tested before shipment.

F. The unit wiring diagram shall be provided in the panel.

2.12 CONTROLS

A. All control end devices (i.e. Damper motors, temperature and pressure sensors/transmitters, low and line voltage wiring, controllers, etc…) are to be furnished and installed by the BMCS contractor.

B. Control equipment and sequence of operation are specified in Section 23 09 00 & 23 09 93, and as otherwise indicated.

2.13 ACCESSORIES

A. Airflow Monitoring Stations (AFMS): AFMS are specified in Section 23 09 00 and will be field installed by the BMCS contractor.

B. Duplex, 115-V, ground-fault-interrupter outlet(s) with 15-A overcurrent protection. Coordinate location of outlet(s) to allow for easy access from anywhere around its respective RTU. Where a single outlet is not fully accessible, provide multiple outlets as required. Power circuit(s) shall be wired by the RTU Manufacturer to a common junction box separate from the VFD or starter so the receptacle(s) can remain on when the main disconnect to the unit is on or off.

C. Lights: Factory installed in all accessible module(s). All light(s) will be factory wired to and controlled by a switch in each respective section. Switches shall be provided with a pilot light. Lighting circuit(s) shall be wired by the RTU Manufacturer to a common junction box separate from the VFD or starter so the lights can remain on when the main disconnect to the unit is on or off.

2.14 ROOF CURBS

A. Roof curbs with wind or seismic restraints are specified in Section 07 72 00.

B. Curb Height: 18 inches (min) to curb top rail, unless otherwise noted. Dimension from the finished roof surface and not the building structural steel, corrugated or concrete decking. Refer to details.

C. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at project site. Comply with requirements in Section 23 05 48 for wind-load requirements.

PART 3 - EXECUTION

3.1 SHIPPING

A. Paper copies of the IOM shall also be shipped with each AHU.

B. The AHU Manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU Manufacturer shall place them in containers.

C. To protect equipment during shipment and delivery, all outdoor units shall be completely shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.

D. After loading the equipment for shipment, the RTU Manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

3.2 ON-SITE STORAGE

A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

3.3 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 LEVELING

A. The Mechanical Contractor shall laser level all unit mounting surfaces, including housekeeping pads, roof curbs, and/or structural steel prior to rigging and installation of the RTU units. Should the RTU units be installed on an unlevel surface, the Mechanical Contractor shall rework the installation at his/her own expense and to the satisfaction of the Owner and Engineer and to ensure proper installation.

3.5 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 07 72 00. Secure RTUs to upper curb rail, and secure curb base to roof framing.

B. Unit Support (Where indicated): Install unit level on structural platform, curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23 05 48.

D. The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or -welded joints, and all other installation and assembly requirements.

E. The RTU Manufacturer shall provide all screws and gaskets for joining of sections in the field.

F. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the RTU Manufacturer's final inspection and start-up:

1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
3. All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
4. All gas piping connections have been completed and tested.
5. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
6. All power wiring, including motor starters and disconnects, serving the unit has been completed.
7. All automatic temperature and safety controls have been completed.
8. All dampers are fully operational.
9. All shipping materials have been removed.
10. All (clean) filter media has been installed in the units.

3.6 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTU coils to allow service and maintenance.

C. Duct installation requirements are specified in other Division 23 sections. Drawings indicate the general arrangement of ducts.

1. Connect supply ducts to RTUs with flexible duct connectors specified in Section 23 33 00.
2. Where ductwork is connected to unit bottom connections (see drawings for unit connections), the following are specific connection requirements:

    a. Install ducts to termination at top of roof curb.
    b. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
    c. Install ducts continuously through roof structure.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections:

1. After installing AHUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Remove packing from vibration isolators.
9. Verify lubrication on fan and motor bearings.
10. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
11. Adjust fan belts to proper alignment and tension.
12. Start unit according to manufacturer's written instructions.

    a. Complete startup sheets and attach copy with Contractor's startup report.

13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for an initial period as recommended or required by manufacturer.
15. Calibrate thermostats.
16. Adjust and inspect high-temperature limits.

17. Inspect dampers for proper stroke.
18. Start system and measure and record the following:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
20. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve. Replace fan and motor pulleys, and sheaves as required to achieve design conditions.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief/exhaust-air volume.
    d. Outdoor-air intake volume.

21. Verify operation of operation and failure modes. Inspect the following:

    a. Low-temperature safety operation.
    b. Filter high-pressure differential alarm.
    c. Economizer to minimum outdoor-air changeover.
    d. Relief-air fan operation.
    e. Smoke and/or firestat alarms.

22. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing AHU and air-distribution systems, clean filter housings and install new filters.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests in accordance with Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 40 hours to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Ceiling-mounted, split air-conditioners w/ air-cooled condensers.

1.3 RELATED SECTIONS

A. Section 01 25 00 - Substitution Procedures.

B. Section 01 26 16 – Contractor's Request for Information: Procedure for submitting a “Request for Information” (RFI), where any discrepancies or questions arise, related to this section or other Division 23 sections and contract documents.

C. Section 01 33 00 - Submittal Procedures.

D. Section 01 77 00 - Closeout Procedures.

E. Section 01 79 00 - Demonstration & Training

F. Section 01 91 13 - General Commissioning Requirements.

G. Section 23 05 00 - Common Work Results for HVAC.

H. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.

I. Section 23 05 48 - Vibration & Seismic Controls For HVAC Piping & Equipment.

J. Section 23 07 00 - HVAC Insulation.

K. Section 23 08 00 - Commissioning of HVAC.

L. Section 23 09 00 - Instrumentation & Control for HVAC.

M. Section 23 09 93 - Sequence of Operations for HVAC Controls.

N. Section 23 23 00 - Refrigerant Piping

O. Section 23 41 00 - Particulate Air Filtration.

1.4 DEFINITION

A. BMCS: Building management control system.

B. DDC: Direct digital control

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: split air-conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For split air-conditioners. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

E. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

F. Seismic Qualification Certificates: For split air-conditioners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control reports.

H. Operation and Maintenance Data: For split air-conditioners to include in emergency, operation, and maintenance manuals.

I. Warranty: Sample of special warranty.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.8 COORDINATION

A. Coordinate layout and installation of split air-conditioners and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate installation of split air-conditioners with computer-room access flooring Installer.

C. Coordinate sizes and locations of concrete bases with actual equipment provided.

D. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split air-conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One (1) set(s) for each belt-driven fan.
2. Filters: One (1) set(s) of filters for each unit.

PART 2 - PRODUCTS

2.1 CEILING-MOUNTED UNITS

A. Provide the product indicated on drawings, no other manufacturers will be considered.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls.

C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch thick duct liner.

1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: R-407C or R-410A.

4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

    a. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

5. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller fan, direct driven.
6. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.

G. Unit shall be provided with a primary and secondary (emergency) condensate drain pans in accordance with the requirements of the IMC-2003.

H. Filter: 1-inch thick, disposable, glass-fiber media.

1. MERV (ASHRAE 52.2): Eight (8).

I. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

J. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature control modules, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch and adjustable temperature set point.

1. BMCS Interface: Factory-installed hardware and software to enable the BMCS to monitor, control, and display unit status and alarms.

    a. ASHRAE 135 (BACnet) communication interface with the BMCS shall enable the BMCS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BMCS.

2.2 FAN MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install split air-conditioners level and plumb, maintaining manufacturer's recommended clearances.

B. Split Air-Conditioner Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Section 23 05 48.

1. Minimum Deflection: 1/4-inch.

C. Suspended Split Air-Conditioners: Install using continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Section 23 05 48. Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 23 05 29.

D. Air-Cooled Refrigerant Condenser Mounting: Install using restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 23 05 48.

1. Minimum Deflection: 1-inch.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Section 22 11 16. Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00. Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Split air-conditioners will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to project during other-than-normal occupancy hours for this purpose.

3.6 COMMISSIONING

A. Engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of commissioning Section 01 91 13.

B. Verify that equipment is installed in accordance with Section 01 91 13 and manufacturer's written instructions.

C. Complete installation and startup checks and functional tests in accordance with Section 01 91 13 and manufacturer's written instructions.

D. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start up procedure.

E. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain split air-conditioners. Refer to Section 01 79 00.

END OF SECTION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.

B. Section 01 31 46- Special Requirements for Mechanical and Electrical Work shall apply.

1.02 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all fan coil units as shown on the drawings and hereinafter specified.

1.03 QUALITY ASSURANCE

A. Manufacturing firms regularly engaged in manufacture of this material with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Provide product produced by the manufacturers, which are listed in Section "Approved Manufacturer's List".

C. Provide equipment whose performance, under specified conditions, is certified by the manufacturer.

1.04 SUBMITTALS

A. Refer to Section 01 31 46- Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.05 COORDINATION

A. Refer to Section 01 31 46- Special Requirements for Mechanical and Electrical Work.

1.06 GUARANTEE

A. Refer to Section 01 31 46- Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.01 FAN COIL UNITS

A. Units: Basic unit shall include chassis, heating coil, cooling coil, dual temperature, water coil, heavy density faced glass fiber insulation, air blockoffs around coils, removable fan board/drain pas assembly, auxiliary drain pan, fans housings, motor and filter. Chassis shall be of galvanized steel with flanged edges. Unit shall have 18 gauge painted steel subbase with slotted leveling adjustment. Unit capacity shall be as scheduled on the Drawings.

B. Water Coils: Separate Hot Water and chilled water coils for four (4) pipe systems dual temperature water coils for two (2) pipe systems shall have seamless copper tubes mechanically bonded to configurated aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 300 psig, factory burst test 450 psi (air) and leak test 300 psi (air under water). Coils shall have female sweat connections to accept f" copper tubing.

C. Drip Pans: Horizontal main drain pans shall be galvanized steel. Drain pan insulation shall be one-piece, self-extinguishing polystyrene foam insulting liner. Auxiliary drainpan shall be provided.

D. Fans: Fan wheels shall be centrifugal, forward curved, double width of molded, fiberglass reinforced, thermoplastic material. Fan housings shall be of molded polyester resin, fiber reinforced material, gradually expanded radially and axially. Wheels and housings shall be non-corrosive.

E. Motor: The motor shall have integral thermal overload protection and start at 78% of rated voltage. The motor shall operate satisfactorily at 90% of rated voltage of all speed settings and at 10% overvoltage without undue magnetic noise. Temperature rise by winding resistance method shall not exceed 55EC. (PSC). Motor shall be 3-speed permanent split capacitor type. The motor shall be factory run tested in assembly unit prior to shipping. The motor cord shall be quickly detachable at switch box by locking pronged connector.

F. Filter: The filter shall be concealed from sight and removable without displacing front panel. The filter shall be throwaway type of woven glass fiber.

G. Enclosure: The enclosure for freestanding units shall be finished with baked-on grey enamel primer and final baked enamel finish, color as selected by the Architect. Enclosures shall be 18 gauge steel. Front and end panels shall have channel-formed edges around entire perimeter. Front panels have faced, heavy-density thermal and acoustical insulation over entire coil section. Front and end panels shall be removable. Discharge diffuser (where enclosures are scheduled to be under another Division) with key locking access door for motor speed switch, shall be under this Section of the Specifications.

H. Controls: The fan coil manufacturer shall furnish a factory wired unit mounted control system that includes a manually-operated fan motor three speed plus off switch, combined with a 4-pipe automatic changeover thermostat in a common junction box and two 2-way electric control valves. The speed switch and thermostat shall be unit mounted below discharge grille access door.

I. Provide piping package including auto air vents, flow measuring /balancing / shot valves and 2-way modulating control valve.

PART 3 - EXECUTION

3.01 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install equipment where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.

B. Coordinate with other work as necessary to interface installation of equipment with other components of systems.

C. Check alignment and, where necessary (and possible), realign shafts of motors and equipment within tolerances recommended by manufacturer.

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, energized with normal power source, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Section 23 05 93- Testing and Balancing.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Steam finned-tube radiators.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Details of custom-fabricated enclosures indicating dimensions.
3. Location and size of each field connection.
4. Location and arrangement of piping valves and specialties.
5. Location and arrangement of integral controls.
6. Enclosure joints, corner pieces, access doors, and other accessories.
7. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members, including wall construction, to which convection units will be attached.
2. Method of attaching convection units to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

E. Color Samples for Initial Selection: For units with factory-applied color finishes.

F. Color Samples for Verification: For each type of exposed finish required.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For convection heating units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 STEAM FINNED-TUBE RADIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Engineered Air.
2. Rittling, a div. of Hydro-Air Components.
3. Rosemex.
4. Slant/Fin.
5. Trane.

B. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One (1) tube end shall be belled.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Rust-Resistant Front Panel: Minimum 0.052-inch thick, ASTM A 653/A 653M, G60 galvanized steel.

F. Wall-Mounting Back Panel: Minimum 0.0329-inch thick steel, full height, with full-length channel support for front panel without exposed fasteners.

G. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless steel escutcheon for floor openings at pedestals.

H. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

I. Finish: Finish and color to be selected by Architect.

J. Damper: Knob-operated internal damper at enclosure outlet.

K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.

L. Enclosure Style: Sloped top.

1. Front Inlet Grille: Punched louver; painted to match enclosure.
2. Top Outlet Grille: Punched louver; painted to match enclosure.

M. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive convection heating units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before convection heating unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FINNED-TUBE RADIATOR INSTALLATION

A. Install units level and plumb.

B. Install finned-tube radiators according to Guide 2000 - Residential Hydronic Heating.

C. Install enclosure continuously around corners, using outside and inside corner fittings.

D. Join sections with splice plates and filler pieces to provide continuous enclosure.

E. Install access doors for access to valves.

F. Install enclosure continuously from wall to wall.

G. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.

H. Install valves within reach of access door provided in enclosure.

I. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.

J. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Sections 23 21 13, 23 22 13 & 23 22 16. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect Steam units and components to piping according to Section 23 22 13 & 23 22 16.

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 23 09 00.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Hydronic, finned-tube radiation heaters.

1.3 ACTION SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.

D. Samples: For each exposed product and for each color and texture specified.

E. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.

F. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which finned-tube radiation heaters will be attached.
2. Method of attaching finned-tube radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATION HEATERS – FT-1

A. Manufacturers: No other Manufacturer or product will be acceptable.

1. Bisque

B. Refer to schedule for performance and other information.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of finned-tube radiation heaters.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FINNED-TUBE RADIATION HEATER INSTALLATION

A. Install in accordance with the manufacturer's installation instructions.

3.3 CONNECTIONS

A. Connect hot-water finned-tube radiation heaters and components to piping according to Section 23 21 13 and Section 23 21 16.

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

B. Install control valves as required by Section 23 09 00.

C. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Cabinet unit heaters with centrifugal fans and hot-water coils.

B. Propeller unit heaters with electric and hot-water coils.

C. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 08 00 - Commissioning of HVAC.

1.4 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.5 SUBMITTALS

A. Submit under provisions of Sections 01 33 00.

B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Details of anchorages and attachments to structure and to supported equipment.
4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
5. Location and arrangement of piping valves and specialties.
6. Location and arrangement of integral controls.
7. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

F. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

G. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 23 05 48. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

H. Field quality-control test reports.

I. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cabinet Unit Heater Filters: Furnish one (1) spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

Non-BOD Manufacturers

1. Airtherm; a Mestek Company.
2. Berko Electric Heating; a division of Marley Engineered Products.
3. Carrier Corporation.
4. Chromalox, Inc.; a division of Emerson Electric Company.
5. Dunham-Bush, Inc.
6. Engineered Air Ltd.
7. Indeeco.
8. International Environmental Corporation.

9. Markel Products; a division of TPI Corporation.
10. Marley Electric Heating; a division of Marley Engineered Products.
11. McQuay International.
12. QMark Electric Heating; a division of Marley Engineered Products.
13. Rosemex Products.
14. Trane.
15. USA Coil & Air.
16. Williams.

2.2 CABINET UNIT HEATERS

A. Description: A factory-assembled and -tested unit complying with ARI 440.

B. Coil Section Insulation: ASTM C1071; surfaces exposed to airstream shall be erosion-resistant coating to prevent erosion of glass fibers.

1. Thickness: 1/2-inch.
2. Thermal Conductivity (k-Value): 0.26 Btu x in/h x sq ft at 75 degrees F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.
4. Adhesive: Comply with ASTM C916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C534, Type II, except for density.

1. Thickness: 1/2-inch.
2. Thermal Conductivity (k-Value): 0.24 Btu x in/h x sq ft at 75 degrees F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Cabinet: Steel with finish and color to be selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessing Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: Minimum 0.0528-inch thick steel, finished to match cabinet, four (4) inches high with leveling bolts.
6. Extended Piping Compartment: 8-inch wide piping end pocket.
7. False Back: Minimum 0.0428-inch thick steel, finished to match cabinet.
8. Outdoor-Air Wall Box: Minimum 0.1265-inch thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with anodized finish in color selected by Architect from manufacturer's standard colors.

    a. Outdoor-Air Damper: Galvanized steel blades with edge and end seals and nylon bearings; with electronic, two-position actuators.

E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated: 90 percent arrestance and 7 MERV.

F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 degrees F. Include manual air vent and drain.

G. Fan and Motor Board: Removable.

1. Fan: Forward curved, high static**,** double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 05 13.
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

H. Factory, Hot-Water Piping Package: ASTM B88, Type L or ASTM B88, Type M copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.

1. Two-way, 2-position control valve.
2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 degrees F. Tag hose kits to equipment designations.

    a. Length: 24 inches.
    b. Minimum Diameter: Equal to cabinet unit heater connection size.

3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 degrees F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
5. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
6. Wrought-Copper Unions: ASME B16.22.

I. Control devices and operational sequences are specified in Sections 23 09 00 and 23 09 93.

J. Electrical Connection: Factory wire motors and controls for a single field connection.

2.3 PROPELLER UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

B. Cabinet: Removable panels for maintenance access to controls.

C. Cabinet Finish: Finish and color to be selected by Architect and applied to factory-assembled and -tested propeller unit heater before shipping.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

E. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

F. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

G. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 degrees F, with manual air vent. Test for leaks to 350 psig underwater.

H. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16-inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 degrees F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless steel or corrosion-resistant material.

I. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

J. Fan Motors: Comply with requirements in Section 23 05 13.

1. Motor Type: Permanently lubricated, multispeed.

K. Control devices and operational sequences are specified in Sections 23 09 00 and 23 09 93.

2.4 WALL AND CEILING HEATERS

A. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

B. Cabinet:

1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.
2. Finish: Finish and color to be selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.

D. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection.

E. Fan: Aluminum propeller directly connected to motor.

1. Motor: Permanently lubricated**,** multispeed. Comply with requirements in Section 23 05 13.

F. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.

G. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 07 72 00.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Section 23 05 48.

E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Section 23 05 29. Vibration hangers are specified in Section 23 05 48.

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install new filters in each fan-coil unit within two (2) weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 23 33 00.

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Section 23 21 13.

G. Ground equipment according to Section 26 05 26.

H. Connect wiring according to Section 26 05 19.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to project during other-than-normal occupancy hours for this purpose.

3.6 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 23 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 23 08 00 and manufacturer's written instructions/requirements.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative for a total of 8 hours to train Owner's maintenance personnel to adjust, operate, and maintain unit heaters. Provide a record of training, including training sign-in sheets that indicate date, times and all attendees. Refer to Section 01 79 00.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Linear radiant-heating hydronic panels.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 23 05 23 - General-Duty Valves for HVAC Piping.

C. Section 23 21 13 - Hydronic Piping.

D. Section 23 08 00 - Commissioning of HVAC.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Details of anchorages and attachments to structure and to supported equipment.
4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
5. Location and arrangement of piping valves and specialties.
6. Wiring Diagrams: Power, signal, and control wiring.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Structural members to which heating panels and suspension systems will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items installed in finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification for Radiant Panel Finishes: 12 by 12 inches.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Panels shall be manufactured by a company regularly engaged in the manufacture of radiant panels having catalogue performance data and certified test data.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate layout and installation of radiant panels and suspension system components with other construction that penetrates ceilings or is supported by them, including column enclosures, light fixtures, HVAC equipment, fire-suppression system, partition assemblies, etc.

PART 2 - PRODUCTS

2.1 LINEAR RADIANT-HEATING HYDRONIC PANELS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one (1) of the following:

1. Aero Tech Manufacturing Inc.
2. Airtite - AR-X. (Basis-of-Design)
3. Price Industries

B. The radiant ceiling extrusions shall consist of extruded aluminum with copper tubing of 0.504in. (12.8mm) I.D. mechanically attached to the aluminum face plate. The copper tube shall be held in place by an aluminum saddle, which extends more than half way around the diameter of the tube. A non-hardening heat conductive paste shall be placed between the copper tubing and the aluminum face plate. The use of adhesive and/or clips to attach the copper tube to the extrusion will not be acceptable.

C. Panels shall run continuously from wall to wall and specified widths are minimum allowable. Refer to the contract drawings for details and additional information.

D. Finish: Finish and color to be selected by Architect.

E. Control devices and operational sequences are specified in Sections 23 09 00 and 23 09 93.

F. Capacities and Characteristics: As indicated in schedule(s) on the Contract Drawings

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating panels for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces in contact with heating panels are free of burrs and sharp protrusions.

2. Ensure surfaces and substrates are level and plumb.
3. Examine roughing-in for piping and/or electrical connections to verify actual locations before heating panel installation.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install radiant-heating panels level and plumb.

B. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than six (6) inches from panel corners.
2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one (1) independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of three (3).

C. All radiant panels shall run continuously from wall-to-wall and shall be field trimmed to length ensuring adequate expansion allowance while maintaining panel end coverage by architectural moldings. Inactive filler panels will be permitted only where indicated on drawings.

D. Ceiling support moldings for Radiant Panels to be supplied and installed by Division 9. Ensure ceiling openings and wall moldings are installed as per radiant panel shop drawings.

E. All panels shall be covered with a minimum of 1in. (25mm) thick batt insulation

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. All interconnecting of radiant panels by the mechanical contractor shall consist of 0.5in. (12.8mm) O.D. soft copper tubing or accessories as recommended by the radiant panel manufacturer, i.e. factory supplied 360 deg. interconnecting loops and 180 deg.

return U-bends. Supply first to panel tubing pass closest to perimeter wall. Multiple panels shall be circuited to ensure serpentine flow over complete length of zone. Individual serpentine panel coils connected in series is unacceptable for multiple panel zones.

D. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Section 23 21 13.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field tests and inspections and prepare test reports:

1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
2. Test and adjust controls and safeties.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Electrical equipment coordination and installation.

B. Sleeves for raceways and cables.

C. Sleeve seals.

D. Grout.

E. Common electrical installation requirements.

1.3 RELATED SECTIONS/REQUIREMENTS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

C. Connecticut State College & Universities “Telecommunication Infrastructure Standards”; Version 4.0, Revision Date: October 24, 2016.

1.4 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For sleeve seals.

1.6 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To provide the proper working clearances as required by the NFPA 70.

2. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
3. To provide for ease of disconnecting the equipment with minimum interference to other installations.
4. To allow right of way for piping and conduit installed at required slope.
5. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Section 08 31 13.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 07 84 13.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052-inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and one (1) or more sides equal to, or more than, 16 inches, thickness shall be 0.138-inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Stainless steel. Include two (2) for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107, factory-packaged, nonmetallic aggregate grout, non-corrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors two (2) inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Section 07 84 13.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Section 07 84 13.

3.5 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Building wires and cables rated 600 V and less.

B. Connectors, splices, and terminations rated 600 V and less.

1.3 RELATED SECTIONS

A. Section 27 15 00 - Communications Horizontal Cabling: Cabling used for voice and data circuits.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Qualification Data: For testing agency.

D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. American Insulated Wire Corp.; a Leviton Company.
2. General Cable Corporation.
3. Senator Wire & Cable Company.
4. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

D. Multi-conductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with steel jacket and Type SO with ground wire.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed/Concealed Homeruns (from panel of origin to general area of construction for each circuit): Type THHN-THWN, single conductors in raceway.

C. Exposed Feeders (from panel of origin to each piece of equipment): Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces (from panel of origin to each piece of equipment): Type THHN-THWN, single conductors in raceway.

E. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground (from panel of origin to each piece of equipment): Type THHN-THWN, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces (wiring within each area of construction): Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions (wiring within each area of construction): Type THHN-THWN, single conductors in raceway and Metal-Clad cable, Type MC with steel jacket.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground (wiring within each area of construction): Type THHN-THWN, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

J. Class 1 Control Circuits: Type THHN-THWN, in raceway.

K. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, which will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Section 26 05 29.

F. Identify and color-code conductors and cables according to Section 26 05 53.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least six (6) inches of slack.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 84 13.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance, homeruns, and feeder conductors for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 6 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Grounding systems and equipment, plus the following special applications:

1. Underground distribution grounding.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" article, including the following:

1. Ground rods.
2. Grounding arrangements and connections for separately derived systems.

D. Qualification Data: For qualified testing agency and testing agency's field supervisor.

E. Field quality-control reports.

F. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NETA MTS.

a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4-inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16-inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16-inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart, minimum 12 inches in length. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two (2) bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, 3/4-inch in diameter by 10 feet long.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers two (2) inches minimum from wall, six (6) inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Exothermically welded connectors except at test wells and as otherwise indicated.
3. Exterior Connections: Exothermically welded connectors or as otherwise indicated.

4. Connections to Structural Steel: Exothermically welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so four (4) inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from two (2) inches above to six (6) inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two (2) ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 3/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than six (6) inches from the foundation.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Homeruns.
3. Lighting circuits.
4. Receptacle circuits.
5. Single-phase motor and appliance branch circuits.
6. Three-phase motor and appliance branch circuits.
7. Flexible raceway runs.
8. Metal-Clad cable runs.

9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

F. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

A. Provide all required grounding to comply with NFPA 70, Article 250 – Grounding and Bonding. Further, all grounding electrodes as described in 250.52(A)(1) through (A)(7) that are present at the building shall be bonded together to form the grounding electrode system.

B. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Ground Rods: Drive rods until tops are two (2) inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three (3) rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one (1) of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding counterpoise (ring) around the building with minimum No. 3/0 AWG, bare copper conductors. Connect each ground rod to building steel and

the grounding counterpoise with No. 3/0 AWG, bare copper conductors and exothermically welded connections. Connect grounding counterpoise to main switchboard with No. 3/0 AWG copper conductor.

3.5 LABELING

A. Comply with requirements in Section 26 05 53 article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two (2) full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical

order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: Five (5) ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: Three (3) ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: One (1) ohm(s).
5. Substations and Pad-Mounted Equipment: Five (5) ohms.
6. Manhole Grounds: 10 ohms.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Hangers and supports for electrical equipment and systems.

B. Construction requirements for concrete bases.

1.3 RELATED SECTIONS

A. Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems: Products and installation requirements necessary for compliance with seismic criteria.

1.4 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. RGSC: Rigid galvanized steel conduit.

1.5 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this project, with a minimum structural safety factor of five (5) times the applied force.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Steel slotted support systems.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include product data for components.
2. Steel slotted channel systems. Include product data for components.
3. Equipment supports.

D. Welding certificates.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A36, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

        1) Hilti Inc.
        2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

    a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Hilti Inc.
        3) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        4) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RGSC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4-inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RGSC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete four (4) inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than four (4) inches thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 50 00 for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 00.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Provide concrete bases for all floor-mounted electrical equipment unless otherwise noted.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 RELATED SECTIONS

A. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems: Exterior ductbanks, manholes, and underground utility construction.

1.4 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. FMC: Flexible metal conduit.

D. LFMC: Liquid tight flexible metal conduit.

E. LFNC: Liquid tight flexible nonmetallic conduit.

F. RNC: Rigid nonmetallic conduit.

G. RGSC: Rigid galvanized steel conduit.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

C. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.

D. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

E. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Section 26 05 48. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For professional engineer and testing agency.

G. Source quality-control test reports.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. O-Z Gedney; a unit of General Signal.
6. Wheatland Tube Company.

B. RGSC: ANSI C80.1.

C. EMT: ANSI C80.3.

D. FMC: Flexible zinc-coated steel.

E. LFMC: Flexible zinc-coated steel conduit with PVC jacket.

F. Fittings for Metal Conduit (Including all Types and MC Cable): NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Fittings for RGSC: Threaded (set-screw type will not be allowed).
2. Fittings for EMT: Set-screw or compression type (where exposed to moisture).
3. Fittings for FMC: Set-screw.
4. Fittings for LFMC: Threaded.
5. Fittings Material: Steel (cast aluminum, cast malleable iron, and cast zinc will not be allowed).
6. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.

G. Joint Compound for RGSC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. CANTEX Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Lamson & Sessions; Carlon Electrical Products.
6. RACO; a Hubbell Company.
7. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Arnco Corporation.
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum, riser or general-use installation.

2.4 METAL WIREWAYS (TROUGHS)

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Thomas & Betts Corporation.
b. Walker Systems, Inc.; Wiremold Company (The).
c. Wiremold Company (The); Electrical Sales Division.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Spring City Electrical Manufacturing Company.
10. Thomas & Betts Corporation.
11. Walker Systems, Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Metal Floor Boxes: Cast iron, fully adjustable, rectangular with brass cover plates and accessories.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

H. Cabinets:

1. NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: RGSC.
2. Concealed Conduit, Aboveground: RGSC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage (Installations above 48” AFF): EMT.
2. Exposed and Subject to Severe Physical Damage (Installations below 48” AFF): Rigid steel conduit. Includes raceways in the following locations:

    a. Loading dock.
    b. Corridors used for traffic of carts and pallet-handling units.
    c. Mechanical rooms.
    d. Electrical rooms.
    e. Stage areas.
    f. Kitchen and servery areas.

3. Stub-ups through slabs and floors: RGSC.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT or MC Cable with steel jacket (Note: all electrical wiring shall be installed concealed unless given written authorization to run surface metal raceway in specific areas).
5. Exposed in Areas Accessible to Building Occupants (Stairwells, Corridors, Classrooms, Offices, etc.): Surface metal raceway (Note: EMT, RGSC, etc. will not be allowed exposed unless otherwise noted).

6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
7. Damp or Wet Locations: RGSC.
8. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
9. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
10. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
11. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Galvanized Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

G. Flush- and surface-mounted boxes, enclosures, troughs, and cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: NEMA 250, Type 5.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this article are stricter.

B. Keep raceways at least six (6) inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Section 26 05 29.

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of four (4) 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal raceways within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit ¾" and larger trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. See structural specifications for exact requirements of inslab conduit installations.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from ENT to rigid steel conduit before rising above the floor.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways longer than 40-feet. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two (2) 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a

flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 degrees F, and that has straight-run length that exceeds 25 feet.

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 degrees F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 degrees F temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 degrees F temperature change.
   d. Attics: 135 degrees F temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041-inch per foot of length of straight run per degrees F of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set metal floor boxes level and flush with finished floor surface.

3.3 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Section 07 84 13.

3.4 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Conduit, ducts, and duct accessories for concrete-encased duct banks and in single duct runs.

B. Handholes and pull boxes.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for handholes, pull boxes, and other utility structures.
4. Warning tape.

C. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

D. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

E. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

F. Product Certificates: For concrete and steel used in precast concrete pull boxes and handholes, comply with ASTM C858.

G. Qualification Data: For qualified professional engineer and testing agency.

H. Source quality-control reports.

I. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Comply with IEEE C2.

B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver ducts to project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate layout and installation of ducts, handholes, and pull boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into handholes, and pull boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to five (5) percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Galvanized Steel Conduit: Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. AFC Cable Systems.
2. Cantex, Inc.
3. CertainTeed Corp.
4. Lamson & Sessions; Carlon Electrical Products.
5. Manhattan Wire Products; a Belden company.

B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC, ASTM F512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and retained to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 26 05 53.

2.3 PRECAST CONCRETE HANDHOLES AND PULL BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Christy Concrete Products.
2. Cretex Concrete Products West, Inc.; Riverton Division.
3. Oldcastle Precast Group.
4. Utility Concrete Products, LLC.

B. Comply with ASTM C858 for design and manufacturing processes.

C. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153 and ASTM A123.

D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and open-bottom enclosures. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing stainless-steel bolts.
2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, as indicated for each service.
4. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches.
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

6. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

a. Windows shall be located no less than six (6) inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
c. Window openings shall be framed with at least two (2) additional No. 4 steel reinforcing bars in concrete around each opening.

7. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

a. Type and size shall match fittings to duct or conduit to be terminated.
b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

8. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.4 HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering,

a. As indicated for each service.
b. Tier level number, indicating that the unit complies with the structural load test for that tier according to SCTE 77.

6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two (2). Handholes and pull boxes shall comply with the requirements of SCTE 7 Tier 8 loading.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Armorcast Products Company.
b. Carson Industries LLC.
c. CDR Systems Corporation.
d. Hubbell Power Systems; Lenoir City Division.

2.5 UTILITY STRUCTURE ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Bilco Company (The).
2. Christy Concrete Products.
3. Cretex Concrete Products West, Inc.; Riverton Division.
4. Hubbell Power Systems; Lenoir City Division.
5. Oldcastle Precast Group.
6. Underground Devices, Inc.
7. Utility Concrete Products, LLC.

B. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM A153 and A123.

C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

D. Pulling Eyes in Non-concrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch diameter eye, rated 2500-lbf minimum tension.

E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

H. Cable Rack Assembly: Steel, hot-dip galvanized except insulators.

1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
2. Arms: 1-1/2 inches wide, lengths ranging from three (3) inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

I. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 degrees F. Capable of withstanding temperature of 300 degrees F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

J. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two (2) required.

2.6 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C1037.

B. Non-concrete Handhole and Pull Box Prototype Test: Test prototypes of pull boxes for compliance with SCTE 77. Strength tests shall be for specified Tier ratings of products supplied.

1. Testing Agency: Engage a qualified testing agency to evaluate non-concrete handholes and pull boxes.
2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 CORROSION PROTECTION

A. Aluminum shall not be installed in contact with earth or concrete.

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables over 600 V: RNC, NEMA Type EPC-80 -PVC, duct bank unless otherwise indicated, installed at a depth below finished grade per the Utility company recommended standards (minimum 36-inch deep to top of conduit).

B. Ducts for Electrical Cables 600 V and Less: RNC, NEMA Type EPC-40-PVC, duct bank unless otherwise indicated, installed at a minimum depth below finished grade of 24-inch deep to top of conduit.

C. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, duct bank unless otherwise indicated, installed at a minimum depth below finished grade of 24-inch deep to top of conduit.

D. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, duct bank unless otherwise indicated, installed at a minimum depth below finished grade of 24-inch deep to top of conduit.

E. Underground Ducts Crossing Paved Paths, Walks and Driveways: RNC, NEMA Type EPC-40-PVC, duct bank unless otherwise indicated, installed at a minimum depth below finished grade of 24-inch deep to top of conduit.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Polymer concrete units SCTE 79, Tier8, structurally tested according to SCTE 77 with 3000-lbf "Light-Duty" vertical loading.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 20 00, but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Sections 32 92 00 and 32 93 00.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Section 01 73 29.

3.5 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two (2) manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 ft from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 ft. outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 05 00.

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

G. Pulling Cord: Install 100-lbf test nylon cord in ducts, including spares.

H. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within three (3) inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE HANDHOLES AND PULL BOXES

A. Precast Concrete Handhole Installation:

1. Comply with ASTM C891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level 6-inch thick bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Install handholes with bottom below the frost line,
2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes one (1) inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three (3) days. Waterproofing materials and installation are specified in Section 07 13 53. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three (3) days.

D. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

E. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and two (2) inches for handholes, for anchor bolts installed in the field. Use a minimum of two (2) anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND PULL BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use pull box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level 6-inch thick bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: Set so cover surface will be flush with finished grade.

D. Install handholes and pull boxes with bottom below the frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Retain arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Section 03 30 00, with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of hand holes and pull boxes. Remove foreign material.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Isolation pads.

B. Spring isolators.

C. Restrained spring isolators.

D. Channel support systems.

E. Restraint cables.

F. Hanger rod stiffeners.

G. Anchorage bushings and washers.

1.3 RELATED SECTIONS

A. Section 26 05 29 - Hangers and Supports for Electrical Systems: Commonly used electrical supports and installation requirements.

1.4 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading: Reference to Structural drawings and specifications.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For the following:
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

C. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
      a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 sections for equipment mounted outdoors.
   2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
   3. Field-fabricated supports.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
      c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Welding certificates.

F. Qualification Data: For professional engineer and testing agency.

G. Field quality-control test reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval by ICC-ES or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. Cooper B-Line, Inc.; a division of Cooper Industries.
   4. Hilti Inc.
   5. Loos & Co.; Seismic Earthquake Division.
   6. Mason Industries.
   7. TOLCO Incorporated; a brand of NIBCO INC.
   8. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one (1) end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A603 galvanized steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two (2) clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E488. Minimum length of eight (8) times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:
   1. Install restrained isolators on electrical equipment.
   2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one (1) supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four (4) of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Identification for raceways.

B. Identification of power and control cables.

C. Identification for conductors.

D. Underground-line warning tape.

E. Warning labels and signs.

F. Instruction signs.

G. Equipment identification labels.

H. Miscellaneous identification products.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each electrical identification product indicated.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, Drawings, shop drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tapes not less than three (3) mils thick by one (1) to two (2) inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, two (2) inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.5 FLOOR MARKING TAPE

A. 2-inch wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one (1) side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: Five (5) mils.
3. Foil Core Thickness: 0.35-mil.
4. Weight: 28 lb/1000 sq ft.
5. 3-Inch Tensile According to ASTM D882: 70 lbf, and 4600 psi.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch thick for signs up to 20 sq inches and 1/8-inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8-inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8-inch. Overlay shall provide a weatherproof and UV-resistant seal for label. For wiring devices only (receptacles, switches, etc.).

B. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8-inch (for panels, transformers, disconnect switches, VFDs, switchboards, starters, ATSs, control panels, etc.)

C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be one (1) inch.

2.10 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one (1) piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16-inch.
2. Tensile Strength at 73 degrees F, According to ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 degrees F.
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one (1) piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16-inch.
2. Tensile Strength at 73 degrees F, According to ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 degrees F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one (1) piece, self locking.

1. Minimum Width: 3/16-inch.
2. Tensile Strength at 73 degrees F, According to ASTM D638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 degrees F.
5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two (2)-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at six (6) to eight (8) inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

I. Painted Identification: Comply with requirements in Division 09 painting sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeders, Homeruns, and Branch Circuits More Than 30 A and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Emergency Power.
2. Normal Power.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of six (6) inches from terminal points and in boxes where splices or taps are made. Apply last two (2) turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
   1. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs and/or Metal-backed, butyrate warning signs.

   1. Comply with 29 CFR 1910.145.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.
   4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

      a. Power transfer switches.
      b. Controls with external control power connections.

J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer, load shedding, etc.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

   1. Labeling Instructions:

      a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two (2) lines of text are required, use labels two (2) inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
      c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchboards.
e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
f. Emergency system boxes and enclosures.
g. Enclosed switches.
h. Enclosed circuit breakers.
i. Enclosed controllers.
j. Variable-speed controllers.
k. Push-button stations.
l. Power transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Power-generating units.
p. Monitoring and control equipment.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

1. Coordination of series-rated devices is permitted where indicated on Drawings.

1.3 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For computer software program to be used for studies.

C. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

D. Qualification Data: For coordination-study specialist.

E. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.
3. Coordination-Study Report.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state where project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one (1) of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

    a. Circuit-breaker and fuse-current ratings and types.
    b. Relays and associated power and current transformer ratings and ratios.
    c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    d. Generator kilovolt amperes, size, voltage, and source impedance.
    e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
    f. Busway ampacity and impedance.
    g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.

e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus.
2. Distribution panelboard.
3. Branch circuit panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers: IEEE C57.96.
2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
3. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 241 and/or IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

    a. Device tag.
    b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
    c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
    d. Fuse-current rating and type.
    e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

    a. Device tag.
    b. Voltage and current ratio for curves.
    c. Three-phase and single-phase damage points for each transformer.
    d. No damage, melting, and clearing curves for fuses.
    e. Cable damage curves.
    f. Transformer inrush points.
    g. Maximum fault-current cutoff point.

F. Completed data sheets for setting of overcurrent protective devices.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For computer software program to be used for studies.

C. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Qualification Data: For Arc-Flash Study Software Developer and Arc-Flash Study Specialist.

C. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 01 78 23, provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by one (1) of the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" article.

E. Short-Circuit Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 05 53. Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective

devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Low-voltage switchgear.
3. Standby generators and automatic transfer switches.
4. Branch circuit panelboards.

3.3 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three (3) to five (5) cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three (3) per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two (2) seconds based on IEEE 1584, Section B.1.2.

3.4 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this project.

B. Gather and tabulate the following input data to support coordination study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.5 LABELING

A. Apply one (1) arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Low-voltage switchboard.
2. Switchgear.
3. Control panel.

3.6 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.7 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. Section 01 91 00 – Building Commissioning Requirements

B. Division 23

C. Division 26 – Electrical

D. Division 27

E. Division 28

1.3 REQUIREMENTS

A. The commissioning process requires the participation of Division 26 "Electrical" to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 26 "Electrical" shall fulfill commissioning responsibilities assigned to Division 26 in accordance with Section 01 91 00.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.

a. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with Section 01 91 00.

b. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. The intent of functional testing is to verify system operation is in accordance with design intent. Thorough test procedures will be utilized to verify systems and equipment through their full sequence of operations.

B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with Section 01 91 00.

C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

c. Pre-Functional Checklists and Functional performance testing procedures will be performed on, but not limited to, the following system types. (Pre-Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 26 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

1. Lighting Controls
2. Emergency Power
3. Variable Frequency Drives
4. Fire Alarm Interlocks with HVAC Systems
5. Security
6. Telecommunications.

3.4 SAMPLE CHECKLISTS

A. See Attached.

Functional Test

Lighting Systems –Exterior/Interior/Stage (Theatrical)

IMPORTANT:

Please refer to the Master Deficiency and Resolution Log for numbers referenced in pren-theses, which will indicate deficiencies discovered and resolved. For quick reference you will find, in the front of this section a list of Master Deficiency and Resolution Log items pertaining only to this section.

1. Submittal / Approvals

Submittal: The above equipment and systems integral to them are complete and ready for functional testing. A Statement of Correction will be submitted upon completion of any outstanding areas.

2. Prerequisite Checklist

a. All associated equipment has been started up, is operational and is ready for functional testing.
b. All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
c. All A/E punchlist items for this equipment corrected.
d. Safeties and operating ranges reviewed.
e. Schedules and setpoints attached.
f. This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
g. Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
h. Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	Lighting	Comments
Lighting		
Devices installed per manufacturer's instructions and specifications		
Lighting control system installed per plans, specifications and manufacturer's recommendations		
Switches and occupancy sensors installed at correct height and have correct cover / escutcheon plate		

The checklist items of Part 3 are all successfully completed for given trade ☐ ***YES*** ☐ ***NO***

4. Operational Checks

Check if Okay. Enter comment or note number if deficient.

Check **Equip Tag➔**	Lighting	Comments
Operational		
Lights are all functioning. No bulbs are burned out		
Lights are not turning on and off frequently causing a disruptions		

The checklist items of Part 4 are all successfully completed for given trade ☐ ***YES*** ☐ ***NO***

5. Functional Testing Record

Lighting Systems

Test#	Mode ID	Test Procedure	Expected Response	Pass Y/N	Note
1	Interior Lighting – Occupancy Sensors	With the room unoccupied and the lights off, enter the space	The occupancy sensor shall see you and the lights shall energize on. While in the space, the lights shall not continually turn off and on.		
2	Interior Lighting – Daylight Dimming	With the room occupied, and the lights on, shine a flashlight on the photocell	The lights should dim as they sense more light in the space.		
2	Exterior Lights On	Engage the time clock/photocell function to simulate a need for the exterior lighting. Cover the Photocell to simulate darkness and override the time clock to simulate a suitable time to be on	All exterior lights should energize on including pole lights, wall packs etc.		
3	Exterior Lights Off	Set the time clock back to normal schedules and remove the covering from the photocell	All exterior lights should turn off including pole lights, wall packs, etc.		
4	Stage / Theatrical Lighting	Try out all functions of the theatrical lighting to ensure that it is working per specification	System should operate the theatrical lighting as setup in accordance with the owners request		

The Functional Tests of Part 5 have all passed for given trade ☐ ***YES*** ☐ ***NO***

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Lighting control devices including the following:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching controls.
4. Indoor occupancy sensors.
5. Outdoor motion sensors.
6. Lighting contactors.
7. Emergency shunt relays.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

C. Section 26 27 26 - Wiring Devices: Wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.4 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

1.7 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.8 WARRANTY

A. Dimming controls: 8-years material and installation.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Invensys Controls.
4. Leviton Manufacturing Co., Inc.
5. NSi Industries LLC.
6. Tyco Electronics Corporation; a TE Connectivity Ltd. Company.

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration: SPST.
2. Contact Rating: 30-A inductive or resistive, 240-V ac.

3. Programs: four (4) channels; each channel shall be individually programmable with two (2) on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
5. Astronomic Time: All channels.
6. Automatic daylight savings time changeover.
7. Battery Backup: Not less than seven (7) days reserve, to maintain schedules and time clock.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.
5. Tyco Electronics Corporation; a TE Connectivity Ltd. Company.

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.3 DAYLIGHT-HARVESTING SWITCHING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Industries, Inc.
2. Eaton Corporation.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.

5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. Sensor Switch, Inc.
8. Tyco Electronics Corporation; a TE Connectivity Ltd. Company.
9. Watt Stopper.

B. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with separate power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.

C. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 degrees F.
3. Sensor Output: Contacts rated to operate the associated power pack, complying with UL 773A. Sensor is powered by the power pack.
4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for one (1) hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
5. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
6. Atrium Space Sensors Light-Level Monitoring Range: 100 to 1000 fc, with an adjustment for turn-on and turn-off levels within that range.
7. Skylight Sensors Light-Level Monitoring Range: 1000 to 10,000 fc, with an adjustment for turn-on and turn-off levels within that range.
8. Time Delay: Adjustable from five (5) to 300 seconds to prevent cycling.
9. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
10. Test Mode: User selectable, overriding programmed time delay to allow settings check.
11. Control Load Status: User selectable to confirm that load wiring is correct.
12. Indicator: Two (2) digital displays to indicate the beginning of on-off cycles.

2.4 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Watt Stopper.

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two (2) lighting conditions:

   a. When no daylight is present (target level).
   b. When significant daylight is present.

2. System programming is done with two (2) hand-held, remote-control tools.

   a. Initial setup tool.
   b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate electronic dimming ballasts. Sensor is powered by controller unit.
3. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
4. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

2.5 INDOOR OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. Philips Lighting Controls.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D.
12. Watt Stopper.

B. General Description: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of one (1) to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
4. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from two (2) to 200 fc; keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq in.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq ft when mounted on a 96-inch high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot high ceiling.

D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq ft when mounted on a 96-inch high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq ft when mounted on a 96-inch high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq ft when mounted on a 96-inch high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq in, and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq ft when mounted on a 96-inch high ceiling.

2.6 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. NSi Industries LLC.
8. Philips Lighting Controls.
9. RAB Lighting.
10. Sensor Switch, Inc.
11. Square D.
12. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 degrees F.
3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq ft.
2. Sensing Technology: PIR.
3. Switch Type: SP, field selectable automatic "on," or manual "on" automatic "off."

4. Voltage: Dual voltage, 120 and 277 V; passive-infrared type.
5. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
6. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.7 OUTDOOR MOTION SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. RAB Lighting.
8. Sensor Switch, Inc.
9. Watt Stopper.

B. General Requirements for Sensors: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Dual-technology (PIR and infrared) type, weatherproof. Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq in. Comply with UL 773A.
3. Switch Rating:

    a. Lighting-Fixture-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent.
    b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for one (1) hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, field selectable automatic "on," or manual "on" automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Dual voltage, 120- and 277-V type.
6. Detector Coverage:

    a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq ft.

b. Long Range: 180-degree field of view and 110-foot detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 degrees F, rated as "raintight" according to UL 773A.

2.8 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a business of Emerson Network Power.
3. Eaton Corporation.
4. General Electric Company.
5. Square D.

B. Description: Electrically operated and mechanically held, combination type with non-fused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

A. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.

1. Monitoring: On-off status.
2. Control: On-off operation.

2.9 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Lighting Control and Design.
2. Wattstopper ELCU-100.
3. ASCO Power Technologies, LP; a business of Emerson Network Power.
4. Eaton Corporation.
5. General Electric Company.
6. Square D.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

2.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19.

B. Classes 2 and 3 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 26 05 19.

C. Class 1 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 26 05 19.

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Section 26 05 19. Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two (2) visits to project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.7 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer’s written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer’s written instructions/requirements.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Section 01 79 00.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Distribution, dry-type transformers rated 600 V and less, with capacities up to 1000 kVA including the following types:

1. Three-phase Harmonic Suppression System integrating a TP-1 transformer with technology to prevent activation of the damaging 3rd harmonic current which wastes usable energy, reduces system capacity, causes excess heat, and costs more to operate.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

1.4 SCOPE

A. Provide for a complete and operational system(s) as shown on the Contract Drawings and specified herein, including, but not limited to, the following:

1. Transformer based Harmonic Suppression System (HSS)

2. Grounding of transformer and HSS

B. It is the intent of this specification to provide low frequency harmonic suppression integral to a 3-phase, 3-wire primary, 3-phase, 4-wire secondary, dry type distribution transformer with features, ratings and options as specified herein:

1. HSS shall be a passive device to be installed at the secondary of a wye-connected distribution transformer at a voltage of 208/120 and at a frequency of 60Hz. The HSS shall reduce the 3rd harmonic current flowing in the phase wires and the neutral wire from the transformer to the farthest outlet.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.

2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

C. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

3. Wiring Diagrams: Power, signal, and control wiring.

D. Informational Submittals:

1. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 26 05 48. Include the following:

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

c. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

d. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2. Qualification Data: For testing agency.

3. Source quality-control test reports.

4. Field quality-control test reports.

E. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain each transformer type through one (1) source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. All products shall be manufactured by a company engaged in the commercial design and production of HSS for a minimum period of 10 years.

1.7 DELIVERY, STORAGE AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.8 PRODUCT LISTINGS

A. Equipment, materials and components for which there are UL, ETL, CSA approvals shall bear the appropriate labels.

B. The specified units shall be designed, manufactured, and tested in accordance with one or more of the following standards:

1. Underwriters Laboratory, UL, 508A.

1.9 WARRANTY

A. Unless otherwise specified, all equipment specified herein is warranted to be free of defects in materials and workmanship under normal use and service for a period of five (5) years from the date of purchase.

1.10 PERFORMANCE SPECIFICATION

A. The HSS shall be totally passive in operation and shall not contain any electronic switching devices such as transistors, SCRs, etc.

B. The HSS shall be entirely self-contained in its own enclosure and shall not require any external enclosures.

C. The HSS shall consist of a single unit per transformer in a 3-phase wye-connected power system.

D. The HSS shall be operative to remove harmonic currents on all 3-phase wires and the neutral wire of a power system loaded with single-phase non-linear loads connected phase to neutral.

E. The HSS shall be protected by the same fuses or circuit breakers that protect the phase wires for the transformer and shall not require any separate fusing for protection.

F. The HSS shall be capable of handling the full rated load of the transformer and shall not require resizing as the transformer is loaded to its full capacity with non-linear loads.

G. The HSS shall block the flow of 3rd harmonic current (180Hz current in the case of a 60Hz fundamental).

H. The HSS shall reduce 3rd harmonic current flow in each of the 3-phase wires, on the secondary of the transformer, from the transformer out to the farthest outlet.

I. The HSS shall reduce RMS current flow in each of the 3-phase wires, on the secondary of the transformer, from the transformer out to the farthest outlet.

J. The HSS shall reduce 3rd harmonic current flow in the neutral wires, on the secondary of the transformer, from the transformer out to the farthest outlet.

K. The HSS shall reduce RMS current flow in the neutral wires, on the secondary of the transformer, from the transformer out to the farthest outlet.

L. The reduction of harmonic currents in the phase wires and neutral wires shall result in increased system capacity to power useful loads.

M. In the event that each circuit consists of a phase wire and an individual neutral wire to each load, the HSS shall reduce 3rd harmonic current flow in every neutral wire in the entire distribution system, on the secondary side of the transformer, from the transformer out to the farthest load.

1.11 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The basis-of-design for these products is Harmonics Limited, New Haven, CT, 877-437-3688. Proposed product substitutions shall be accompanied by a fully completed compliance review documenting that the proposed substitution is in full compliance with all 13 items (1.10, A-M) of the performance specification. Substitutions that are not fully compliant with all requirements shall be deemed unacceptable.

2.2 ALTERNATIVE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. General Electric Company.
3. Power Quality International
4. Siemens Energy & Automation, Inc.
5. Square D; Schneider Electric.

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Cores: One (1) leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

F. Taps for Transformers 3 kVA and Smaller: None.

G. Taps for Transformers 7.5 to 24 kVA: One (1) 5 percent tap above and one (1) 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two (2) 2.5 percent taps above and four (4) 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 degrees C, UL-component-recognized insulation system with a maximum of 115-degrees C rise above 40-degrees C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 degrees C, UL-component-recognized insulation system with a maximum of 150-degrees C rise above 40-degrees C ambient temperature.

K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

L. Wall Brackets: Manufacturer's standard brackets.

M. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
1. 9 kVA and Less: 40 dBA.
2. 30 to 50 kVA: 45 dBA.
3. 51 to 150 kVA: 50 dBA.
4. 151 to 300 kVA: 55 dBA.
5. 301 to 500 kVA: 60 dBA.
6. 501 to 750 kVA: 62 dBA.
7. 751 to 1000 kVA: 64 dBA.
8. 1001 to 1500 kVA: 65 dBA.

N. Harmonic suppression system shall consist of a 3-phase, 3-wire primary, 3-phase 4-wire secondary, dry type transformer with a series connected neutral harmonic suppression system which are factory wired and enclosed in a NEMA 1 construction.

O. Transformer/ Harmonic Suppression System performance ratings shall be as follows based on 208/120-volt secondary:

MODEL	FULL LOAD kVA	RATING IN AMPS
HLTM015	15	42
HLTM030	30	83
HLTM045	45	125
HLTM075	75	208
HLTM112	112.5	311
HLTM150	150	416
HLTM225	225	625
HLTM300	300	833
HLTM500	500	1388

P. Dry type distribution transformer shall have the following characteristics and features:

1.	kVA rating	As indicated on drawings
2.	Input voltage	480 volt delta
3.	Output voltage	208 volt, 3-phase, 4 wire, wye
4.	Insulation class	220 degree C
5.	Temperature class	115 degree C rise
6.	Mechanical	Core and coil
7.	Winding material	Copper
8.	Electrostatic shield	Yes
9.	Taps	2 x 2.5% FCAN and 2 x 2.5% FCBN
10.	Enclosure	Type 1
11.	Energy Efficiency rating	Per NEMA TP-1-2002; FAR 10 CFR, Parts 430 and 431

2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:
    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.
9. Temperature tests.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 03 30 00 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges

G. Confirm voltage, kVA rating, and frequency of device with load and building distribution system characteristics prior to installation.

H. Coordinate exact locations and mounting of device with architect/owner/owner's representative/other trades prior to installation.

I. Provide mounting or seismic restraints as required by local codes, etc.

J. Make sure that the system onto which the HSS is to be installed is de-energized before starting installation.

K. Install per manufacturer's written instructions making sure to implement proper wiring and grounding.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Prior to energizing the device, verify the following:

1. System voltage and frequency are correct.

2. Devices are properly rated for loads being served.

3. Wiring is in full compliance with manufacturer's instructions.

4. Primary and secondary over current protective devices are installed per codes.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two (2) months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two (2) follow-up infrared scans of transformers, one (1) at four (4) months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Distribution panelboards.

B. Lighting and appliance branch-circuit panelboards.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

1.4 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated.

Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Include selectable ranges for each type of overcurrent protective device.

D. Qualification Data: For qualified testing agency.

E. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 26 05 48. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

H. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.8 DELIVERY, STORAGE AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.9 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 degrees F to plus 104 degrees F.

b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.10 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion, materials and installation.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two (2) spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two (2) spares for each panelboard.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.

B. Enclosures: Flush- and surface-mounted cabinets (as shown on the drawings).

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
   d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: NEMA 250, Type 5.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

3. Finishes:

   a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Galvanized steel.

4. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

C. Incoming Mains Location:

1. Top and/or bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 degrees C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type.
5. Ground Lugs and Bus-Configured Terminators: Compression type.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Five (5) percent.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two (2) latches, keyed alike.

D. Mains: Circuit breaker or Lugs only (as shown on the drawings).

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or Lugs only (as shown on the drawings).

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings for circuit-breaker frame sizes 250 A and larger:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
    g. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.

h. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 26 05 48.

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

I. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

J. Install filler plates in unused spaces.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

L. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53.

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53.

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Receptacles, receptacles with integral GFCI, and associated device plates.

B. Twist-locking receptacles.

C. Isolated-ground receptacles.

D. Tamper-resistant receptacles.

E. Wall-box motion sensors.

F. Snap switches and wall-box dimmers.

G. Solid-state fan speed controls.

H. Wall-switch and exterior occupancy sensors.

I. Pendant cord-connector devices.

J. Cord and plug sets.

K. Floor service outlets, poke-through assemblies, and multi-outlet assemblies.

1.3 RELATED SECTIONS

A. Section 27 15 00 - Communications Horizontal Cabling: Workstation outlets.

1.4 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. UTP: Unshielded twisted pair.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated.

C. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one (1) source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one (1) source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.8 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

1.9 EXTRA MATERIALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Service Outlet Assemblies: One (1) for every 10, but no fewer than one (1).
2. Poke-Through, Fire-Rated Closure Plugs: One (1) for every five (5) floor service outlets installed, but no fewer than two (2).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
5. Eaton Wiring Devices; Arrow Hart (Eaton)

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this section.

D. Devices to be decorator style.

2.3 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper
b. Hubbell
c. Leviton
d. Pass & Seymour
e. Eaton; 6352.

B. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper
b. Hubbell
c. Leviton
d. Pass & Seymour
e. Eaton;TR6352

2. Description: Labeled to comply with NFPA 70.

3. Tamper-resistant receptacles will be provided wherever children have access to the receptacle location.

C. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).
e. Eaton

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent

electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 GFCI RECEPTACLES

A. General Description: Straight blade, feed -through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper.
b. Pass & Seymour
c. Eaton

2. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Pass & Seymour/Legrand (Pass & Seymour).
c. Eaton

C. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Pass & Seymour/Legrand (Pass & Seymour).
c. Eaton

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. See drawings for additional configurations.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper.
b. Hubbell
c. Leviton.
d. Pass & Seymour
e. Eaton

2.6 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.7 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

B. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).
e. Eaton

2. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.8 COMMERCIAL GRADE TOGGLE SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A, (single-pole, two-pole, three-way, four-way):

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper;
b. Hubbell
c. Leviton
d. Pass & Seymour
e. Eaton

C. Pilot Light Switches, 20 A:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper;
b. Hubbell
c. Leviton
d. Pass & Seymour
e. Eaton

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper
b. Hubbell
c. Leviton
d. Pass & Seymour
e. Eaton

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper
b. Hubbell.
c. Leviton
d. Pass & Seymour
e. Eaton.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Cooper
b. Hubbell.
c. Leviton.
d. Pass & Seymour
e. Eaton

2.9 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

D. LED Light Dimmer Switch: Coordinate requirements with each manufacturer of the light fixtures (i.e., auditorium seat lights, auditorium step lights, etc.).

2.10 FAN SPEED CONTROLS

A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.

1. Continuously adjustable rotary knob.
2. Three-speed adjustable rotary knob, 1.5 A.

2.11 OCCUPANCY SENSORS

A. Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

   a. Hubbell; AT120 for 120 V, AT277 for 277 V.
   b. Leviton; ODS 15-ID.
   c. Watt Stopper (The).

2. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq ft.

B. Long-Range Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

   a. Hubbell; ATD1600WRP.
   b. Leviton; ODW12-MRW.
   c. Watt Stopper (The); DT-200.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq ft.

C. Wide-Range Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

   a. Hubbell; ATP120HBRP.
   b. Leviton; ODWHB-IRW.
   c. Pass & Seymour; HS1001.
   d. Watt Stopper (The); CX-100-3.

2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq ft.

D. Exterior Occupancy Sensors:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Hubbell.
b. Leviton; PS200-10.
c. Watt Stopper (The); EW-100-120.

2. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.12 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch thick, satin finished, type 302 stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.13 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular solid brass with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Two (2) modular, keyed, color-coded, RJ-45 Category jacks for UTP cable.

F. See plan drawing for exact information on specific installations in the auditorium and student center.

2.14 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
3. Square D/ Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold Company (The).

B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Comply with UL 514 scrub water exclusion requirements.
2. Service Outlet Assembly: Flush type with four (4) simplex receptacles and space for four RJ-45 jacks complying with requirements in Section 27 15 00..
3. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.
4. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
5. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.
6. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four (4), 4-pair, Category 5e voice and data communication cables.

2.15 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Square D/ Schneider Electric.
3. Wiremold / Legrand.

B. Description:

1. Two-piece surface metal raceway, with factory-wired multi-outlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.

D. Multioutlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: 12 inches.
3. Wiring: No. 12 AWG solid, Type THHN copper, single circuit.

2.16 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.

b. Straighten conductors that remain and remove corrosion and foreign matter.
c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than six (6) inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Section 26 05 53.

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of six (6) percent or higher is not acceptable.
3. Ground Impedance: Values of up to two (2) ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Cartridge fuses rated 600-V ac and less for use in control circuits and enclosed switches.

B. Spare-fuse cabinets.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 degrees F or more than 100 degrees F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.7 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10percent of quantity installed for each size and type, but no fewer than two (2) of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, fast acting.
2. Feeders: Class L, time delay.
3. Motor Branch Circuits: Class RK5, time delay.
4. Other Branch Circuits: Class J, fast acting.
5. Control Circuits: Class CC, fast acting.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the drawings or as indicated in the field by the architect.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

3.5 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Fusible switches.

B. Non-fusible switches.

C. Shunt trip switches.

D. Molded-case circuit breakers (MCCBs).

E. Enclosures.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

1.4 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

C. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

D. Qualification Data: For qualified testing agency.

E. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

G. Manufacturer's field service report.

H. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
2. Altitude: Not exceeding 6600 feet.

1.9 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two (2) for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.
5. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three (3) padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 SHUNT TRIP SWITCHES (for elevator)

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.

2. Oiltight red ON pilot light.
3. Isolated neutral lug; 100 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting for circuit-breaker frame sizes 250 A and larger.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings for circuit-breaker frame sizes 250 A and larger:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

I. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Zone-Selective Interlocking: Integral with ground-fault trip unit; for interlocking ground-fault protection function.
8. Accessory Control Power Voltage: Integrally mounted, self-powered 120-V ac.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 26 05 48.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 26 05 53.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.

3.6 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.

1.3 RELATED SECTION

A. Section 26 29 23 - Variable-Frequency Motor Controllers: General-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.4 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

C. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.7 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Qualification Data: For qualified testing agency.

C. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

F. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.8 CLOSEOUT SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.

1.9 MATERIALS MAINTENANCE SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three (3) of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two (2) of each size and type.
3. Indicating Lights: Two (2) of each type and color installed.
4. Auxiliary Contacts: Furnish one (1) spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three (3) spares for each size and type of magnetic contactor installed.

1.10 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16.

1.11 DELIVERY, STORAGE AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.12 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 degrees F and not exceeding 104 degrees F.
2. Altitude: Not exceeding 6600 feet.

1.13 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Surface mounting.
4. Red pilot light.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Surface mounting.
5. Red pilot light.

D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Rockwell Automation, Inc.; Allen-Bradley brand.
    d. Siemens Energy & Automation, Inc.
    e. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.
4. Surface mounting.
5. Red pilot light.
6. N.O. auxiliary contact.

E. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Manufacturers: Subject to compliance with requirements, [provide products by one (1) of the following:

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Rockwell Automation, Inc.; Allen-Bradley brand.
    d. Siemens Energy & Automation, Inc.
    e. Square D; a brand of Schneider Electric.

2. Configuration: Non-reversing.
3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 50 VA.

6. Solid-State Overload Relay:

    a. Switch or dial selectable for motor running overload protection.
    b. Sensors in each phase.
    c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    e. Analog communication module.

7. N.O., isolated overload alarm contact.
8. External overload reset push button.

F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Rockwell Automation, Inc.; Allen-Bradley brand.
    d. Siemens Energy & Automation, Inc.
    e. Square D; a brand of Schneider Electric.

2. Fusible Disconnecting Means:

    a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
    b. Lockable Handle: Accepts three (3) padlocks and interlocks with cover in closed position.

3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
4. Non-fusible Disconnecting Means:

    a. NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.
    b. Lockable Handle: Accepts three (3) padlocks and interlocks with cover in closed position.
    c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

5. MCP Disconnecting Means:

    a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-

mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three (3) padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. N.O. alarm contact that operates only when MCP has tripped.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

6. MCCB Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: Accepts three (3) padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. N.O. alarm contact that operates only when MCCB has tripped.

2.2 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen and Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.3 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, type.

a. Push Buttons: Flush types; momentary as indicated.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.

B. Reversible N.C./N.O. auxiliary contact(s).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 05 29.

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 03 30 00.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 26 05 48.16.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch enclosed controller.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13.

G. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 26 05 23.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six (6) times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

C. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.

3.7 PROTECTION

A. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 RELATED SECTIONS

A. Section 01 91 03 - Building Commissioning Requirements.

B. Section 26 08 00 - Commissioning of Electrical Systems.

1.4 DEFINITIONS

A. BMS: Building management system.

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. OCPD: Overcurrent protective device.

F. IGBT: Integrated gate bipolar transistor.

G. LAN: Local area network.

H. PID: Control action, proportional plus integral plus derivative.

I. PWM: Pulse-width modulated.

J. VFC: Variable frequency controller.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

C. Shop Drawings: For each VFC.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Nameplate legends.
c. Short-circuit current rating of integrated unit.
d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

E. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Section 26 05 48. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For manufacturer.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
2. Manufacturer's written instructions for setting field-adjustable overload relays.
3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
5. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
6. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain VFCs of a single type through one (1) source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) years from date of Substantial Completion.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 0 to 40 degrees C.
2. Humidity: Less than 90 percent (non-condensing).
3. Altitude: Not exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.10 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00.

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.11 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Furnish one (1) spare for every five (5) installed, but no fewer than one set of three (3) of each type and rating.
2. Indicating Lights: Two (2) of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
2. Eaton Corporation; Cutler-Hammer Products.
3. General Electric Company; GE Industrial Systems.
4. Siemens Energy and Automation; Industrial Products Division.
5. Square D.

2.2 VARIABLE FREQUENCY CONTROLLERS

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Constant torque and variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, bypass motor controller, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one (1) or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

A. Output Rating: Three (3) phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 10 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

B. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding five (5) percent.
3. Input Frequency Tolerance: Plus or minus three (3) percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Vibration Withstand: Comply with NEMA ICS 61800-2.
7. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
8. Starting Torque: 100 percent of rated torque or as indicated.
9. Speed Regulation: Plus or minus one (1) percent.

C. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.

D. Internal Adjustability Capabilities:

1. Minimum Speed: Five (5) to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

E. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three (3) selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

F. Automatic Reset/Restart: Attempts three (3) restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

G. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

H. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

I. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.

6. External fault.

J. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three (3) levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four (4) conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

K. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four (4) faults with time and date stamp for each.

L. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

M. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of two (2) analog inputs (0 to 10 V dc or 4- to 20-mA) and six (6) programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

a. 0 to 10-V dc.
b. 4-20 mA.
c. Fixed frequencies using digital inputs.

d. RS485.
e. Keypad display for local hand operation.

3. Output Signal Interface:

a. A minimum of one (1) analog output signal (4- to 20-mA), which can be programmed to any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of two (2) dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. Set-point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

N. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

a. Monitoring: On-off status.
b. Control: On-off operation.

2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

A. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
3. NO alarm contact that operates only when circuit breaker has tripped.

B. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Kitchen or Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Non-corrosive Liquids: Type 12.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Reversible NC/NO bypass contactor auxiliary contact(s).

E. Control Relays: Auxiliary and adjustable time-delay relays.

F. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

G. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).

6. Motor speed (rpm).
7. Motor output voltage (V).

H. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four (4) faults with time and date stamp for each.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 05 29.

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 26 05 48.16.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Section 26 28 13.

F. Comply with NECA 1.

3.4 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Section 26 05 00, and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Section 26 05 53.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Section 26 05 23.

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Section 26 05 26.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
3. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. VFCs will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.9 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight (8) times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.

E. Set field-adjustable pressure switches.

3.10 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

3.11 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative in a 2-4 hours session to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Section 01 79 00.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Interior solid-state luminaires that use LED technology.

B. Exit Signs.

C. Lighting fixture supports.

1.3 RELATED REQUIREMENTS

A. Section 26 08 00 – Commissioning of Electrical Systems

B. Section 26 09 23 - Lighting Control Devices: Automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multi-pole lighting relays and contactors.

C. Section 26 27 26 – Wiring Devices: Manual wall-box dimmers.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.5 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this project, IES LM-79, and IES LM-80.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

C. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.2: For paints and coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.6 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and/or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

7. Moldings.

C. Qualification Data: For testing laboratory providing photometric data for luminaires.

D. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

E. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Product Certificates: For each type of luminaire.

G. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

H. Sample warranty.

1.7 CLOSEOUT SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on project; use ANSI and manufacturers' codes.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one (1) of each type.
2. Diffusers and Lenses: One (1) for every 100 of each type and rating installed. Furnish at least one (1) of each type.
3. Globes and Guards: One (1) for every 20 of each type and rating installed. Furnish at least one (1) of each type.

1.9 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.

2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.10 DELIVERY, STORAGE AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.11 WARRANTY

A. Warranty: Manufacturer and installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period:

1. Five (5) year(s) for ballasts from date of Substantial Completion, material and installation.

2. Ten (10) year(s) for batteries from date of Substantial Completion, material and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61.

G. CRI of minimum 85. CCT of 3000 K.

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: 120 V ac and/or 277 V ac.

L. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

M. Housings:

1. Extruded-aluminum housing and heat sink.
2. Powder-coat painted finish.

2.3 CYLINDER

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 575 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. With integral mounting provisions.

2.4 DOWNLIGHT

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.5 HIGHBAY, LINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

2.6 RECESSED LINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.7 STRIP LIGHT

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.8 SURFACE MOUNT, LINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.9 SURFACE MOUNT, NONLINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

C. Integral junction box with conduit fittings.

2.10 SUSPENDED, LINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.11 SUSPENDED, NONLINEAR

A. Manufacturers: As indicated on the plan drawings.

B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

C. Integral junction box with conduit fittings.

2.12 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2.13 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared

receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.14 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Tempered Fresnel glass, prismatic glass, diffuse glass, prismatic acrylic, or clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One (1) hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Powder-coat painted finish.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.15 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved samples and if they can be and are assembled or installed to minimize contrast.

2.16 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four (4) points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount with two (2) 5/32-inch diameter aircraft cable supports adjustable to 120 inches in length.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one (1) point and tubing or rod for suspension for each unit length of luminaire chassis, including one (1) at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.

2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four (4) locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four (4) locations, spaced near corners of luminaire.

J. Comply with requirements in Section 26 05 19 for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.7 COMMISSIONING

A. Where indicated in the equipment or commissioning specifications engage a factory-authorized service representative to perform startup service as per functional test sheets and requirements of Sections 01 91 03 and 26 08 00.

B. Complete installation and startup checks and functional tests according to Section 01 91 03 and manufacturer's written instructions.

C. Operational Test: After electrical system has been energized start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new ones and repeat the start-up procedure.

D. Verify that equipment is installed and commissioned as per requirements of Sections 01 91 03 and 26 08 00 and manufacturer's written instructions/requirements.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within **12** months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to **two (2)** visits to project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

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PART 1 - GENERAL

1.1 SUMMARY

A. Work of this Section consists of Architectural Lighting, and includes but is not limited to the following:

1. Interior lighting fixtures with lamps and drivers
2. Luminaire Schedule

B. Related Documents and Sections: Examine Contract Documents for requirements that directly affect or are affected by Work of this Section. A list of those Documents and Sections includes, but is not limited to the following:

1. Drawings and general provisions of the Contract, including General and Supplementary conditions and General Requirements, Division 01 Specification Sections, apply to this Section.
2. Division 26 Section “Emergency Lighting”
3. Division 26 Section “Exit signs”
4. Division 26 Section "Lighting Controls" for manual or programmable control systems employing low-voltage control wiring or data communication circuits.
5. Division 26 Section "Wiring Devices" for manual wall-box dimmers.
6. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multiple lighting relays and contactors.
7. Division 26 Section "Dimming Controls" for architectural dimming systems.
8. Division 26 Section “Wire and Cables”
9. Division 26 Section "Basic Electrical Materials and Methods.”

1.2 DEFINITIONS

A. Fixture: The elements of a luminaire that are designed to distribute the light, and to position and protect the lamps.

B. Luminaire: A complete lighting unit consisting of a lamp or lamps and ballasting (when applicable) together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to the Power Supply.

C. Lighting Unit: A fixture or an assembly of fixtures with a common support, including a pole or bracket plus mounting and support accessories.

D. Average Rated Life: The time after which 50 percent of the lamps fail and 50 percent of the lamps survive under normal conditions.

E. Rated Lumen-maintenance Life (LED light sources): The elapsed operating time at which the specified percentage of the lumen depreciation or lumen maintenance is reached, expressed in hours. Measured in hours with associated percentage of light output, noted as Lp. e.g. L70 of 50,000 hours means that the tested LEDs produce 70% of the initial light output at 50,000 hours.

F. CRI: Color rendering index.

G. CU: Coefficient of utilization.

H. LER: Luminaire efficiency rating, which is calculated according to NEMA LE 5. This value can be estimated from photometric data using the following formula:

1. LER is equal to the product of total rated lamp lumens times BF times luminaire efficiency, divided by input watts.

I. RCR: Room cavity ratio.

1.3 QUALITY ASSURANCE

A. Fixture Materials: Provide fixture parts and components that are constructed of materials most appropriate to their use or function, and that are resistant to corrosion in a marine environment and mechanical stresses encountered in the normal application and function of the fixtures.

B. Manufacturers: Provide fixtures from manufacturers making like products for not less than five years prior to bid.

C. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL.

D. Listing and Labeling: Provide fixtures and accessory components specified in this Section that are listed and labeled for their indicated use and installation conditions on Project.

1. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, and recessed in combustible construction, that are specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for the specific hazard.
2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
3. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

E. Applicable Codes: Fixtures shall be made and installed in accordance with the current version of the National Electric Code, the Uniform Building Code, the Federal

Occupational Safety & Health Act, local codes, and other applicable regulations.

F. Measuring and Testing Equipment: Instruments for the measurement of voltage, luminaire temperature, lighting level and fixture brightness level shall be available at all times on the site.

1.4 BIDS & SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections, unless noted otherwise.

1. Bids and submittals shall include itemized unit pricing by fixture type, as labeled in the Luminaire Schedule and Drawings. Unit pricing shall describe any special conditions, such as an adder for custom colors, quantity discount, special warranties, etc.

B. Substitutions:

1. Where multiple names are included in specification provide one of the specified manufacturers wherever possible.
2. Contractor-offered substitutions beyond those named within the Luminaire Schedule in this Section must meet or exceed the aesthetic, dimensional and performance characteristics of the specified products. The lighting designer reserves the right to reject substitution submittals that do not meet the requirements of the application. In that event one of the specified products would have to be resubmitted.
3. Some luminaires included in this specification are unique designs, available only from the specified manufacturer. No attempt shall be made to solicit bids from Alternate manufacturers: to copy or “knock-off” these luminaires.
4. Some luminaires included in this specification are listed as having no alternate manufacturers. Where this is the case, it is because the lighting designer was unable to find a product for specification that met the requirements of the application. In these cases, the Contractor shall submit the specified product.

C. Product Data: Fixtures, lamps, drivers and mounting components. Arrange Product Data for fixtures in order of fixture type, as labeled in the Luminaire Schedule. Include data on features and accessories and the following:

1. Outline drawings indicating dimensions and principal features of fixtures.
2. Electrical Ratings and Photometric Data: Certified results of independent laboratory tests for fixtures and lamps. Provide data for the specified lamp or lamp/ballast combination.
3. Lamp Data: Manufacturer, ordering code and technical information.
4. Driver Data: Manufacturer, ordering code and technical data showing compliance with requirements.

a. Where a fixture manufacturer will utilize ballasts from multiple manufacturers depending on availability, technical data must indicate the minimum characteristics that will be met in all cases. In the case of system input watts, the technical data must indicate the maximum wattage that will be met in all cases.
   i. In order to assure compliance with energy codes and to achieve calculated illumination levels, driver factor and input watts may not vary from the specification.
   ii. Submittal Data must include information on driver factor and input watts.
b. Manufacturer is responsible for confirming that the submitted ballast products work within the fixture in terms of case size and wire lead lengths.
c. Where remote drivers have limitations in distance, manufacturer shall clearly indicate maximum wire lead distance and any other requirements necessary to allow the ballast mounting locations to be properly coordinated by the Contractor.

D. Provide data as required to demonstrate that the submitted product meets or exceeds the performance of the specified fixture.

1. Include photometric data charts: C.U., candlepower distribution and/or luminance information as necessary.
2. Where technical charts alone cannot substantiate compliance, the submitting manufacturer may be required to provide a full photometric study of a specific project application for verification.

E. Scaled shop drawings detailing nonstandard fixtures and indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled at not less than half full size.

1. Scaled shop drawings of continuous run fixtures shall indicate overall length of each run, lamp combinations used to achieve the length and any accessory components required.
   a. Track and illuminated handrails are considered continuous run fixtures

F. Wiring diagrams detailing wiring for control system coordination showing both factory-installed and field-installed wiring for specific system of this Project, and differentiating between factory-installed and field-installed wiring.

G. Coordination Drawings showing fixtures mounted on, in, or above ceiling. Indicate coordination with ceiling grids and other equipment installed in vicinity.

H. Product certificates signed by manufacturers of lighting fixtures certifying that their products comply with specified requirements.

I. Field test reports indicating and interpreting test results specified in Part 3 of this Section.

J. Maintenance data for fixtures, lamps and ballasts, to include in the operation and maintenance manual specified in Division 1.

1. Data shall include warranty information, lamp and ballast life and replacement costs, as well as other fixture information required in Division 1.

1.5 WARRANTY

A. General Warranty: The special warranty specified in this Article shall be in addition to, and run concurrent with, other warranties made under requirements of the Contract Documents.

B. LED Fixture Warranties: Warrant complete LED systems, including LEDs, drivers, and all other system components for 5 years minimum against failure, variation in color temperature beyond plus/minus 200K, and depreciation of output below 70%.

1.6 DELIVERY, STORAGE AND HANDLING

A. Delivery: Luminaires and lighting equipment shall be delivered to the project complete, including mounting devices, lamps and components necessary for the proper operation of the equipment.

B. Marking: All equipment must be clearly and boldly identified as to the fixture type and, where practicable, the fixture location.

1. Voltage identification: Fixtures designed for voltages other than 110-125 volt circuits shall be clearly marked.
2. Lamp/ballast coordination: Fixtures equipped with ballasts for operation of rapid start lamps shall be plainly marked "Use Rapid Start Lamps Only". Similarly, fixtures equipped with ballasts or other components requiring use of specific types of lamps shall be plainly marked. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when lamps are in place.

C. Timely Purchase: Luminaires, associated lamps and other allied equipment shall be ordered in a timely fashion and securely stored to be available to meet the project schedule.

D. Storage: Contractor shall store all fixtures in locations where they will be protected against damage due to moisture, dust, extreme temperatures and/or the work of other project construction trades.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Lamps: 10 lamps for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts, Transformers and Drivers: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
5. Louvers and Reflector Cones: 1 for every 100 of each type. Furnish at least one of each type.
6. Custom Luminaires: When 10 identical custom fixtures are furnished, furnish one complete spare custom fixture as attic stock.
7. LED Modules: 1 for every 50 of the same type, from the same production run as the installed products.
8. Tools: Furnish manufacturer's recommended number of each tool required to service and maintain the fixtures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: For lighting fixtures to be incorporated into the Work, see the products specified in the Luminaire Schedule at end of this Section.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Sheet Metal Components: Provide the required dimensional thickness of metal, plastic and composite materials so that all fixtures are rigid, stable and will resist deflection, twisting, warping under normal installation, and relamping procedures.

1. All luminaire housings shall be minimum 0.84mm cold rolled steel, unless a heavier gauge is specified or required by code.
2. All aluminum extrusion housings shall be minimum 5mm thick.
3. All spun, hydro-formed or sheet aluminum reflectors shall be fabricated from #12 aluminum sheets minimum, 1.45mm or heavier. Material shall be 3002 alloy, 99.5% pure aluminum with uniform grain structure.
4. All spun aluminum housings shall be of an alloy of the 5000 series (ANSI/ASTM-B209-1977) or of an alloy that is found to have equal corrosion resistance.

B. Joints: Provide positive, durable, means of connection at all joints as required. No hollow rivets, unless specifically approved.

C. Gaskets: Provide neoprene, silicone, rubber, or other appropriate gaskets, stops, and barriers where required to prevent light leak, control sound and vibration, prevent water leaks and, if pertinent, water vapor penetration.

D. Edges: Provide finished product with the following minimum qualities:

1. Ground and/or burr free metal edges.
2. Tight fitting connections, hinges and closures.
3. Clean neat corners, edges, trims and frames.

E. Castings: All cast parts, including die-cast members, shall be of uniform quality; free from blow holes, pores, hard spots, shrinkage defects, cracks and or other imperfections that affect strength and appearance, or are indicative of inferior metals or alloys.

F. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallic Film: 90 percent.

G. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water-white, annealed crystal glass, except as otherwise indicated. Soda-lime glass lenses are not acceptable. Heat resistant where required: borosilicate or Pyrex glass.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: 0.125 inch (3 mm) minimum; except where greater thickness is indicated.

H. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

I. Fixture Support Components: Comply with Specification Section on "Basic Electrical Materials and Methods."

1. Single-Stem Hangers: 1/2-inch (12-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.

2. Twin-Stem Hangers: Two, 1/2-inch (12-mm) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
3. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
4. Hook Hanger: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
5. Aircraft cable: Minimum 1/16" diameter aircraft cable, 48" length, field adjustable, with canopy size to match at feed and non-feed locations, and 18/3, 18/4 or 18/5 straight flexible cord, U.O.N. Canopy finish to match ceiling.

J. Track-Lighting Systems: Provide components, including track, fittings, and fixtures, from same manufacturer and as recommended by manufacturer for intended use.

1. Maintain a continuity of conductors through feeds, splices, and boxes. The relative positions of live and neutral conductors must always be maintained along a continuous run so that track fittings connect into the track in a consistent manner.

2. Install surface mounted track straight and true regardless of the ceiling contour.

2.3 FINISHES

A. Manufacturer's standard, except as otherwise indicated, applied over corrosion-resistant treatment or primer, free of streaks, runs, holidays, stains, blisters, and similar defects.

1. Prior to finishing, all surfaces must be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
2. Where necessary, surface cleaned by accepted chemical means shall receive corrosion inhibiting phosphating treatment assuring positive paint adhesion.
3. All castings and extrusions shall be machined, sanded or similarly treated, and given minimum one coat of baked-on clear methacrylate lacquer, unless a painted finish is specified.
4. Aluminum surfaces exposed to weather (other than anodized reflectors covered elsewhere) receive a duronodic or polyester powder paint finish as specified for corrosion resistance.
5. Sheet steel fixture housings, iron and steel parts, which have not received phosphating treatment ("Bonderizing" or similar process) or are to be utilized in exterior applications, are to be made corrosion resistant by zinc or cadmium plating or hot-dip galvanizing. All plating or hot-dipping shall be performed after parts are fabricated.
6. Anodized aluminum reflectors required for exterior use shall have a minimum of 0.2 mils anodizing thickness
7. Anodized reflectors for interior use shall have a minimum of .006mm (.25mils) anodizing thickness for clear reflectors. Specular reflectors shall have 86% to 91%

reflectivity. All reflectors shall be double sealed, first in Nickel Acetate and then in Sandoz Andal sealant at a minimum of 208 deg. All Specular reflectors shall meet or exceed the specification for the Alzak process.

2.4 LAMPS

A. Solid State Lighting / Light Emitting Diodes (LEDs):

1. All individual LEDs used within a luminaire must be manufactured by a reputable LED manufacturer, such as Cree, Osram Sylvania, Nichia, Philips (Lumileds). LED modules shall be manufactured by Bridgelux, Philips (Fortimo) or Xicato.

2. Testing: All products shall be tested by a Nationally Recognized Testing Laboratory (NRTL) in accordance with IES LM-79 testing methods and shall carry a UL, ETL or CSA label. Fixture manufacturer shall confirm in writing that the LEDs within the fixture will not exceed the maximum temperature to which the LED die was tested using IES LM-80 testing methods.

3. Drive Current, Thermal Management and LED rated Life: Drivers must not over-drive the LEDs beyond LED manufacturer's recommendations and shall adhere to device manufacturer guidelines, certification programs, and test procedures for thermal management of LEDs within their fixtures. Drive current and luminaire thermal design must ensure minimum 50,000 hour rated life for the LEDs.

4. Color Consistency: All LEDs from the same manufacturer, both within each luminaire and from luminaire to luminaire, must be batch-sorted for visual color and brightness consistency. All luminaires of the same type shall be supplied at the same time and shall come from the same batch. Spare luminaires shall be provided from the same batch.

5. Dimming: Luminaire manufacturer must provide specific data on the means of dimming for coordination of the proper control device (specified elsewhere). Acceptable methods include electronic low voltage dimming and 0-10V 4-wire Power Supply. Dimming must provide uniform, smooth, full-range dimming. LEDs must maintain consistent brightness and color throughout the dimming range.

6. Technology Upgrades: Supply the newest LED technologies that are available for the specified products when the orders are released, as long as there are no increases in input watts or cost.

7. Warranty: See Part 1.5 C. above for the warranty requirement for LED luminaire systems.

2.5 LAMP HOLDERS

A. Screw base: Screw base sockets shall be of heavy duty heat resistant porcelain with spring center contacts and plated screw shells.

2.6 LED DRIVERS

A. Provide line voltage LED product, where available, to eliminate the need for drivers. If the LED product is not available as line voltage, then the LED drivers shall meet the following requirements:

1. Drivers shall have a minimum efficiency of 85%
2. Starting Temperature: -40° C
3. Input Voltage: capable of 120 to 480 (±10%) volt, single phase or as required by the site
4. Power supplies can be UL Class I or II output
5. Surge Protection: The system must survive 250 repetitive strikes of “C Low” (C Low – 6kV/1.2 x 50 µs, 10kA/8 x 20 µs) waveforms at 1 minute intervals with less than 10% degradation in clamping voltage. “C Low” waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C
6. Drivers shall have a Power Factor (PF) of: ≥ 0.90
7. Drivers shall have a Total Harmonic Distortion (THD) of: ≤ 20%
8. Drivers shall comply with FCC 47 cfr part 18 non-consumer RFI/EMI standards
9. Drivers shall be Reduction of Hazardous Substances (RoHS) compliant (see http://www.rohs.eu/english/index.html)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings. Support fixtures according to requirements of Specification Section on "Basic Electrical Materials and Methods.”

1. Install square aperture fixtures parallel to walls; UON. Verify that fixture is parallel prior to completion of ceiling installation.
2. Verify that wallwasher housings have been properly installed to allow for reflector orientation to wash the intended wall.

B. Support for Recessed and Semi-recessed Grid-Type Fluorescent Fixtures: Units may be supported from suspended ceiling support system, unless prohibited by local codes. No movement permitted after installation. Install ceiling support system rods or wires at a minimum of 4 rods or wired for each fixture, located not more than 6 inches (150 mm) from fixture corner.

1. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.
2 Fixtures Smaller than Ceiling Grid: For fixtures that normally mount at the ceiling grid on at least one side, install a minimum of 4 rods or wires for each fixture and locate at corner of ceiling grid where fixture is located. Provide additional ceiling grid to frame out fixture. Do not support fixtures by ceiling acoustical panels. Example: 1x4 fixture in 2x4 panel.
3. Fixtures of Sizes Less than Ceiling Grid: Center in acoustical panel. Support fixtures independently with at least two ¾ inch (20 mm) metal channels spanning and secured to ceiling tees. Example: Recessed 6" aperture downlight in 2x2 panel.

C. Support for Suspended Fixtures: Brace pendants and rods over 48 inches (1200 mm) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent fixtures with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod or aircraft cable for suspension for each unit length of chassis, including one at each end.
   1. Provide all mounting components required for installation, including hickeys, stud-extensions, ball-aligners, canopies and stems.

   2. Provide stems on pendant fixtures of the correct length to uniformly maintain the fixture heights shown on the drawings or established in the field.

D. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution. Do not screw through housings in a manner that will restrict lamp adjustability. Confirm requirements based on manufacturers' cut sheets or contact manufacturer if necessary to verify mounting method.

E. Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's instructions.

F. Installation Sequence: Install fixture mounting frames, plaster rings, etc. prior to the trim assembly, which shall not be installed until the project is "broom clean". Where the fixture location or construction does not permit sequential installation, all reflectors, lenses, flanges and other visible surfaces shall be carefully protected

3.2 WIRING

A. Minimum standards: All wiring shall comply with the following standards:

   1. All wiring within lighting fixtures or from the splice with the building wiring shall be as specified under Division 26 "WIRE AND CABLES".
   2. Wiring between fluorescent lamp holders and associated operating and starting

equipment shall be of similar or heavier gauge than the leads furnished with the approved ballasts.

3. Wire leads to the receptacle or connector of any side prong incandescent lamp or any "cool-beam" lamp, or any lamp 200 watts or over shall be SF-2 (silicone rubber insulated) stranded wire.
4. Wiring within fixture construction is to be concealed, except where the fixture design or mounting dictates otherwise.
5. Joints in wiring within lighting fixtures and connections of the fixture wiring to the wiring of the building shall be as specified under "WIRE AND CABLES" with special attention to paragraphs relating to high amperage, low voltage conditions.
6. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout, and at all points or edges over which conductors must pass and may be subject to injury or wear.
7. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.

3.3 GROUNDING

A. Ground fixtures according to Specification Section on "Grounding." Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values.

3.4 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components, prior to scheduling punchlist review.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results.

D. Tests: Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source.

E. Replace or repair malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

F. Report results of tests.

G. Replace fixtures that show evidence of corrosion during Project warranty period.

3.5 CLEANING AND ADJUSTING

A. Clean fixtures after installation: Remove all protective strippable coatings, dust, finger marks, paint spots and any materials deleterious to the appearance or functioning of the

fixtures. Use methods and materials recommended by manufacturer. Abrasive cleaners are not permitted.

B. Focusing and adjustment: After installation of all lighting fixtures, finishes and furnishings has been completed, the Contractor shall provide personnel, ladders or lifts, spare lamps and any other equipment necessary to expeditiously focus (aim) all adjustable lighting. Focusing shall be performed after dark, unless all visible daylight can be screened out of the focusing area, and shall take place under supervision of the Lighting Designer. All work shall be performed in accordance with union rules, should they be in force, and applicable codes. Where pre-aiming diagrams or angles have been provided by the Lighting Designer, this information shall be considered preliminary aiming, which is being provided to help expedite the process of night focusing. Pre-aiming by the Contractor does not eliminate the requirement for final focusing after dark.

C. Lighting interface with dimming control systems: Where lighting is being controlled on a dimming system (specified elsewhere), the system shall be up and running at the time of final focusing so that the Lighting Designer may provide input on dimmed preset levels. Technical personnel from the dimming manufacturer shall be on hand at final focusing to adjust the light levels and coordinate with the Lighting Designer.

3.6 FINAL INSPECTION

A. Upon completion of the installation, lighting equipment must be in first class operating order and free from defects in condition and finish.

1. At time of final inspection, all fixtures and equipment must be installed and lamped with new lamps and be complete with all lenses, diffusers, reflectors, side panels, louvers or other necessary components. Lamps that have been operating longer than the following time limits or that have already burned out must be replaced with new lamps prior to final completion.

    a. Halogen incandescent lamps: 200 hours (approximately 25 eight-hour days).
    b. Non-halogen Incandescent lamps: 75 hours (approximately 9 eight-hour days).
    c. Fluorescent lamps: 1000 hours (approximately 125 eight-hour days).
    d. HID lamps: 1000 hours (approximately 125 eight-hour days).

2. Fixtures shall be completely clean and free from finger marks, dust, plaster or paint spots.
3. Any reflectors, lenses, diffusers, side panels or other parts damaged prior to the final inspection shall be replaced.
4. Where finish has been scratched or damaged on exterior fixtures, repair finish to match factory color.
5. Housings shall be rigidly installed and adjusted to a neat flush fit with the ceiling.

6. No light leaks shall be permitted at the ceiling line or from any visible part or joint.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
Student Center Lighting			
SL1	Pendant mounted cylinder LED fixture – 4" diameter 24" in length Location: Dining	CCT: White 3000K CRI: 85 Output: 1600 lm Watts: 22W Voltage: Electrical Engineer to verify Dimming Protocol: Lutron 3 wire or Ecosystem; Electrical Engineer to confirm Control Protocol: Lutron system; Electrical Engineer to confirm system type.	VISA CP2020-L30K-RMB-SILVER STEM & WHITE CANOPY-XPS Architect to verify silver stem and white canopy finish; Contractor to coordinate remote driver location Manufacturer has confirmed that the stems supporting the fixtures can withstand the air diffuser velocities in the 35-100 fpm range without movement Alternate manufacturers: MP Lighting Delray Lighting
SL2	Not used		

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL3	Recess mounted LED downlight – 2" diameter Location: Banquet	CCT: White 3000K CRI: 90+ Output: 750 Watts: 9.5W Voltage: MVOLT Dimming Protocol: 0-10V Control Protocol: Lutron system; Electrical Engineer to confirm system type	Gotham ICO 30/07 2AR LSS 25D-MVOLT-UGZ-TRW-CRI90-OPTC240D-NCH Architect to verify white flange finish; provide additional 40-degree optic for field installation; new construction housing; Electrical Engineer to coordinate 0-10V dimming with compatible dimming module and interface for control system being provided Alternate manufacturers: Edison Price Zumtobel
SL4	Surface mounted LED window light – mounted on window sill Location: Dining	CCT: White 3000K CRI: 85 Output: 620 lm Watts: 6W Voltage: 120-277V Dimming Protocol: NON-DIM Control Protocol: Lutron system; Electrical Engineer to confirm system type	IGuzzini BU27-UNV-01 Architect to verify white finish; contractor to coordinate mounting; integral driver

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL5	Exterior Surface mounted linear LED flood uplight – 48" in length Location: Exterior sunshade	CCT: White 3000K CRI: 90+ Output: 425 lm/ft. Watts: 6W/ft. Voltage: Electrical Engineer to verify Dimming Protocol: ELV type 0.07%-100%, Reverse Phase, Trailing Edge Control Protocol: Electrical Engineer to confirm	ECOSENSE L50-E-48-06-30-90-MULT-40x60-(mounting) Louver: LV-L50-ASYM-48 Contractor to coordinate accessories for complete system; Architect and Contractor to coordinate mounting detail; Electrical Engineer and Contractor to coordinate ELV with compatible dimming interface or module for control system being provided Alternate manufacturers: Color Kinetics Lumenpulse

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL5A	Exterior Surface mounted linear LED flood uplight – 12" in length Location: Exterior sunshade	CCT: White 3000K CRI: 90+ Output: 425 lm/ft. Watts: 6W/ft. Voltage: Electrical Engineer to verify Dimming Protocol: ELV type 0.07%-100%, Reverse Phase, Trailing Edge Control Protocol: Electrical Engineer to confirm	ECOSENSE L50-E-12-06-30-90-(MULT)-40x60-(mounting) Louver: LV-L50-ASYM-12 Contractor to coordinate accessories for complete system; Architect and Contractor to coordinate mounting detail; Electrical Engineer and Contractor to coordinate ELV with compatible dimming interface or module for control system being provided Alternate manufacturers: Color Kinetics Lumenpulse

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL6	Exterior surface mounted cylinder downlight LED – 5" diameter Location: Exterior sunshade	CCT: White 3000K CRI: 90+ Output: 3300 lm Watts: 31W Voltage: Electrical Engineer to verify Dimming Protocol: Dimming driver for use with standard 0-10V dimmers and switch controls; 0.1-100% range Control Protocol: Electrical Engineer to confirm	BK Lighting SM-AP-LED-x44-WFL-(finish)-12-11-E Wide flood (60 degrees); soft focus lens; honeycomb baffle; Architect to select finish; remote driver is required – Architect and Contractor to coordinate remote driver location; Contractor to coordinate driver size and quantity; maximum remote distance is 50 foot overall wiring distance using 12 gage wire; Contractor to coordinate mounting detail; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: BEGA ERCO

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL7	Exterior in-ground round LED flood uplight – 8" diameter Location: Building Perimeter	CCT: White 3000K CRI: 85+ Output: 819 lm Watts: 10.9W Voltage: Electrical Engineer to verify Dimming Protocol: Integral 120V-277V electronic LED driver, 0-10V dimming Control Protocol: Electrical Engineer to confirm	BEGA 7913LEDK3 To be installed in pre-cored holes at the ground level; Contractor to coordinate mounting detail; #4 brushed stainless steel finish; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: BK Lighting ERCO
SL8	Exterior surface mounted LED compact floodlight at corner Location: Exterior sunshade	CCT: White 3000K CRI: 80+ Output: 4,225 lm Watts: 48.2W Voltage: Electrical Engineer to verify Dimming Protocol: Integral 120V or 277V electronic LED driver, 0-10V dimming Control Protocol: Electrical Engineer to confirm	BEGA 7653LEDK3-(finish) Architect to specify finish; Contractor to coordinate mounting detail; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: Lumenpulse ERCO

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL9	Recess mounted LED downlight – 4" diameter Location: Dining	CCT: White 3000K CRI: 95+ Output: 3000 lm Watts: 36.9W Voltage: Electrical Engineer to verify Dimming Protocol: Lutron® Hi Lume® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Lutron system; Electrical Engineer to confirm system type	Gotham EVO 30/30 4AR MD LSS MVOLT ECOS3 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel
SL10	Recess mounted LED downlight – 4" diameter Location: Stair Vestibule	CCT: White 3000K CRI: 95+ Output: 3000 lm Watts: 36.9W Voltage: Electrical Engineer to verify Dimming Protocol: Lutron® Hi Lume® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Electrical Engineer to confirm	Gotham EVO 30/30 4AR MD LSS MVOLT ECOS3 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL10A	Recess mounted LED downlight – 4" diameter Location: Entrance Vestibule	CCT: White 3000K CRI: 95+ Output: 1500 lm Watts: 17.3W Voltage: Electrical Engineer to verify Dimming Protocol: Lutron® Hi Lume® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Electrical Engineer to confirm	Gotham EVO 30/15 4AR MDW LSS MVOLT ECOS3 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel
SL11	Recess mounted linear lensed LED – nominal 1.5" wide x 27'-6" long Location: Servery	CCT: White 3000K CRI: 90+ Output: 519 lm/ft Watts: 6.4W/ft Voltage: Electrical Engineer to verify Dimming Protocol: Lutron® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Lutron system; Electrical Engineer to confirm system type	SELUX L36-1A25-30-LW-(mounting)-27-6"-WH-(voltage)-(Lutron driver)-(options) Drywall flange; Architect to specify finish; Contractor to coordinate length and mounting detail; Electrical Engineer to coordinate EM requirement Alternate manufacturers: AXIS Zumtobel

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL11A	Recess mounted linear lensed LED – nominal 1.5" wide x 29'-3" long Location: Servery	CCT: White 3000K CRI: 90+ Output: 519 lm/ft Watts: 6.4W/ft Voltage: Electrical Engineer to verify Dimming Protocol: Lutron® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Lutron system; Electrical Engineer to confirm system type	SELUX L36-1A25-30-LW-(mounting)-27-6"-WH-(voltage)-(Lutron driver)-(options) Drywall flange; Architect to specify finish; Contractor to coordinate length and mounting detail; Electrical Engineer to coordinate EM requirements Alternate manufacturers: AXIS Zumtobel

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL12	Surface mounted 0.2" wide flexible LED tape - curved Location: Servery	CCT: White 3100K CRI: 85+ Output: 95 lm/ft Watts: 2.4W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 0-10V Control Protocol: Lutron system; Electrical Engineer to confirm system type	LED LINEAR Vario LED FLEX AMOR W827/ L IP67 Architect and Contractor to coordinate mounting with counter detail; contractor to coordinate length and accessories for complete system; Contractor to coordinate remote driver location; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Feelux Acolyte

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL13	Surface mounted 0.2" wide flexible LED tape - straight Location: Servery	CCT: White 3100K CRI: 85+ Output: 95 lm/ft Watts: 2.4W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 0-10V Control Protocol: Lutron system; Electrical Engineer to confirm system type	LED LINEAR Vario LED FLEX AMOR W827/ L IP67 Architect and Contractor to coordinate mounting with counter detail; contractor to coordinate length and accessories for complete system; Contractor to coordinate remote driver location; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Feelux Acolyte

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL14	Recess mounted LED downlight – 4" diameter Location: Servery cashier area	CCT: White 3000K CRI: 95+ Output: 750 lm Watts: 10.3W Voltage: MVOLT Dimming Protocol: Lutron® Hi Lume® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Lutron system; Electrical Engineer to confirm system type	Gotham EVO 30/07 4AR MD LSS MVOLT ECOS3 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel
SL15	Recess mounted LED – Techzone compatible 6" wide linear lensed fixture – 8' long nominal Location: Servery	CCT: White 3000K CRI: 90+ Output: 500 lm/ft Watts: 4.3W/ft Voltage: UNV Dimming Protocol: 0-10 volt dimming standard Control Protocol: Lutron system; Electrical Engineer to confirm system type	AXIS B6RLED B3 MF 500 90 30 2M 8 W UNV D (mounting – techzone) Architect to verify white finish; Contractor to coordinate fixture trim detail with ceiling type; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Pinnacle 3G

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL15A	Recess mounted LED – 6" wide linear lensed fixture – 12' long nominal Location: Servery	CCT: White 3000K CRI: 90+ Output: 500 lm/ft Watts: 4.3W/ft Voltage: UNV Dimming Protocol: 0-10 volt dimming standard Control Protocol: Lutron system; Electrical Engineer to confirm system type	AXIS B6RLED B3 MF 500 90 30 2M 12 W UNV D (mounting – techzone) Architect to verify white finish; Contractor to coordinate fixture trim detail with ceiling type; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Pinnacle 3G
SL16	Recess mounted LED downlight – 6" diameter Location: Servery	CCT: White 3000K CRI: 90+ Output: 3000 lm Watts: 36.6W Voltage: MVOLT Dimming Protocol: Lutron® Hi Lume® 3-wire or EcoSystem® dimming driver; Minimum dimming level 1%; Electrical Engineer to confirm driver type Control Protocol: Lutron system; Electrical Engineer to confirm system type	Gotham EVO 30/30 6AR MD LSS MVOLT ECOS3 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL17	Recess mounted 4.25" wide LED perimeter linear fixture with corners Location: Servery	CCT: White 3000K CRI: 95+ Output: 445 lm/ft Watts: 6.5W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 100W constant current driver, 0-10V 2% Dimming Control Protocol: Lutron system; Electrical Engineer to confirm system type.	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 30 AD (voltage) FA ECO (corners) Contractor to coordinate lengths and mounting detail - see architectural drawing Contractor to coordinate corner configurations; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL17A	Recess mounted 4.25" wide LED perimeter linear fixture Location: Servery	CCT: White 3000K CRI: 95+ Output: 445 lm/ft Watts: 6.5W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 100W constant current driver, 0-10V 2% Dimming Control Protocol: Lutron system; Electrical Engineer to confirm system type.	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 30 AD (voltage) FA ECO Contractor to coordinate lengths and mounting detail - see architectural drawing; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL17B	Recess mounted 4.25" wide LED perimeter linear fixture Location: Servery	CCT: White 3000K CRI: 95+ Output: 445 lm/ft Watts: 6.5W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 100W constant current driver, 0-10V 2% Dimming Control Protocol: Lutron system; Electrical Engineer to confirm system type.	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 30 AD (voltage) FA ECO Contractor to coordinate lengths and mounting detail - see architectural drawing; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL17C	Recess mounted 4.25" wide LED perimeter linear fixture Location: Servery	CCT: White 3000K CRI: 95+ Output: 445 lm/ft Watts: 6.5W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 100W constant current driver, 0-10V 2% Dimming Control Protocol: Lutron system; Electrical Engineer to confirm system type.	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 30 AD (voltage) FA ECO (corners) Contractor to coordinate lengths and mounting detail - see architectural drawing; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL17D	Recess mounted 4.25" wide LED perimeter linear fixture Location: Servery	CCT: White 3000K CRI: 95+ Output: 445 lm/ft Watts: 6.5W/ft Voltage: Electrical Engineer to verify Dimming Protocol: 100W constant current driver, 0-10V 2% Dimming Control Protocol: Lutron system; Electrical Engineer to confirm system type.	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 30 AD (voltage) FA ECO (corners) Contractor to coordinate lengths and mounting detail - see architectural drawing Contractor to coordinate corner configurations; Electrical Engineer and Contractor to coordinate 0-10V with compatible dimming interface or module for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SL18	Recess mounted LED downlight – 4" diameter Location: 1st Floor Corridor	CCT: White 3000K CRI: 95+ Output: 750 lm Watts: 10.3W Voltage: MVOLT Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	Gotham EVO 30/07 4AR WD LSS MVOLT EZB TRW Architect to verify white flange finish; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Edison Price Zumtobel
SL18A	Recess mounted LED downlight – 4" diameter Location: 1st Floor Corridor	CCT: White 3000K CRI: 95+ Output: 1400 lm Watts: 27.4W Voltage: MVOLT Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	Gotham EVO LW 30/14 4AR MVOLT EZB TRW Architect to verify white flange finish; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Edison Price Zumtobel
SL19	Not used		

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
Student Center – Site Lighting			
SLX1	Pole mounted LED pedestrian light attached to 5”-2.4” tapered round pole – overall 12’-4” height Location(s): Exterior Ramps and Stairs	CCT: White 3000K CRI: +80 Output: 3,406 lm Watts: 35W Voltage: 120-277V Dimming Protocol: 0-10V Control Protocol: Compatible dimming control is required; Electrical Engineer to coordinate	Louis Poulsen LP PARK-35W LED/3000K-120-277V-(FINISH)-TAPER-5 IN-2.4 IN-DIM 0-10V-5747920105 Pole: TAPER-5-2.4 / 10 FT / (FINISH) / NOT APPLICABLE / 10000138464 Architect to select finish for fixture and pole; Landscape Architect to coordinate mounting location with handrail; provide fixture sample for final approval; Architect has confirmed 3000K Alternate manufacturers: BEGA HESS

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾”) may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
SLX2	Exterior wet location surface mounted wall LED sconce, direct light with Type IV distribution, fixture dimensions nominally 8"L x 8" H x 3.75" D Location: Multiple	CCT: White 3000K CRI: 85+ Output: 1598 lm Watts: 30W Voltage: 120-277V Dimming Protocol: non-dim Control Protocol:	BEGA 33 242 (finish) TYPE IV distribution with back light control; Architect to specify finish and verify 4000K color temperature Alternate manufacturers: ERCO PRISMA

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
Theater Lighting			
TL1	Pendant mounted cylinder downlight LED – 6" diameter Location: Theater	CCT: White 3000K CRI: +95 Output: 3500 lm Watts: 48W Voltage: MVOLT Dimming Protocol: eldoLED POWERdrive DMX Control Protocol: DMX	Gotham ICO CYL 30/35 6AR (finish) 40D MVOLT EDXB PM (powder paint) Architect to specify housing finish; 40-degree beam; 1% dimming; eldoLED Power Drive DMX with RDM (remote device management) Alternate manufacturers: Edison Price Zumtobel
TL2	Recessed LED downlight – 4" diameter Location: Theater	CCT: White 3000K CRI: 95+ Output: 2000 lm Watts: 23.5W Voltage: MVOLT Dimming Protocol: eldoLED Power Drive DMX Control Protocol: DMX	Gotham EVO 30/20 4AR MVD LSS MVOLT EDXB (flange finish) 1% dimming; eldoLED Power Drive DMX with RDM (remote device management); Architect to select flange finish Alternate manufacturers: USAI Meteor

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL2A	Recess mounted LED downlight – 4" diameter Location: Restrooms	CCT: White 3000K CRI: 95+ Output: 2000 lm Watts: 23.5W Voltage: MVOLT Dimming Protocol: non dim Control Protocol: Electrical Engineer to confirm	Gotham EVO 30/20 4AR MVD LSS MVOLT EZ1 TRW Architect to verify white flange finish Alternate manufacturers: Edison Price Zumtobel
TL3	Surface mounted - 3/4" wide LED linear fixture Location: Theater wall	CCT: White 3000K CRI: 85+ Output: 1,188 lm/lf Watts: 11 W/lf Voltage: Electrical Engineer to verify Dimming Protocol: DMX Driver Control Protocol: DMX	LED LINEAR XOOLINE HYD HD36 830/ (length) – 10D-C004-IP40–eldoLED driver (M100) Contractor to coordinate run length and accessories for complete system; linear lens for 10-degree beam; Architect and Contractor to coordinate mounting detail
TL3A	NOT USED		

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL4	Surface mounted incandescent style strip light with open ended wire guards at each lamp - designed for use with medium base lamps Location: Theater Dressing Rooms	GREEN CREATIVE A19 Lamp 9A19G4DIM/927 CCT: 2700K thru 5000K CRI: 90+ Output: 800 lumens Watts: 9W per lamp Voltage: 120V Dimming Protocol: See attached dimming chart for compatible dimmer types Control Protocol: Electrical Engineer to coordinate compatible dimming control	COLE LIGHTING VS-6”-WG-6’6” Contractor to coordinate run lengths based on mirror configuration – see architectural drawings; Contractor to coordinate quantity of A19 lamps
TL5	Recessed perimeter mounted LED linear wallwasher - 4” wide Locations: Restrooms	CCT: 3000K CRI: 90+ Output: 445lm/ft. Watts: 6.5W Voltage: Electrical Engineer to verify Dimming Protocol: non dim Control Protocol: Electrical Engineer to confirm	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 35 AD (voltage) FA NX Contractor to coordinate run length; contractor to coordinate mounting with ceiling type Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾”) may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL5A	Recessed perimeter mounted LED linear vanity light - 4" wide Locations: Restrooms	CCT: 3000K CRI: 90+ Output: 445lm/ft. Watts: 6.5W Voltage: Electrical Engineer to verify Dimming Protocol: non dim Control Protocol: Electrical Engineer to confirm	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 35 AD (voltage) FA NX Contractor to coordinate run length; contractor to coordinate mounting with ceiling type Alternate manufacturers: A Light Pinnacle
TL5B	Recessed perimeter mounted LED linear wallwasher - 4" wide Locations: Ticket office	CCT: 3000K CRI: 90+ Output: 445lm/ft. Watts: 6.5W Voltage: Electrical Engineer to verify Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	MARK ARCHITECTURAL LIGHTING SPRL (length) (ceiling trim) N 35 AD (voltage) FA NX Contractor to coordinate run length; contractor to coordinate mounting with ceiling type; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: A Light Pinnacle

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL6	Recessed 6" round wet location LED shower light Location: Restroom	CCT: 3000K CRI: 90+ Output: 1000lm/ft. Watts: 9.6W Voltage: MVOLT Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	GOTHAM EVO-30/10-6-DFD-MVOLT-EZ1 Wet location; Contractor to coordinate mounting accessories if needed Alternate manufacturers: Edison Price Zumtobel
TL7	Recessed mounted LED Step Light Locations: Theater Corridors	CCT: 3000K CRI: 90+ Output: 60lm Watts: 17.3 Voltage: 120-277V Dimming Protocol: 0-10V Control Protocol: Wall box dimmer with lock; Electrical Engineer to coordinate for compatible dimming control	WINONA STEO12-RND-M-LST1A-350mA-WHT30K-MVOLT-DMD-(finish) Architect to coordinate mounting with wall pattern; Contractor to coordinate mounting detail; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: BEGA Lucifer

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL8	Recessed lensed LED linear - 4" wide Locations: Dressing	CCT: 3500K CRI: 90+ Output: 564 lm/ft. Watts: 6 W/ft Voltage: 277 Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	MARK ARCHITECTURAL LIGHTING SL4L LOP (length) RLP (ceiling trim) 90CRI 35K 600LMF MIN1 ZT 277 Architect to specify finish; Contractor to coordinate length and mounting detail; Electrical Engineer to coordinate EM requirement; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Axis Selux
TL9	Pendant mounted indirect LED linear in 8' x 14' rectangular configuration Locations: Green Room	CCT: 3000K CRI: Output: 702lm/ft Watts: 9W /ft Voltage: UNV Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to confirm	SELUX L361-1A35-30-BW-XX-WH-UNV-DIM-(options) Architect to verify white finish; shop drawing is required for final approval; Contractor to coordinate mounting with ceiling condition Alternate manufacturers: Axis Mark Lighting

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL10	Surface mounted linear under cabinet task light Locations: Green Room	CCT: 3000K CRI: 80 Output: 601 Watts: Voltage: Electrical Engineer to confirm Dimming Protocol: no dimming Control Protocol:	JUNO LIGHTING UPLED (length)-(finish) Architect to select finish; Contractor to coordinate fixture lengths for continuous run – see millwork detail; Contractor to coordinate accessories for complete system Alternate manufacturers: Tech Lighting WAC
TL11	Recessed mounted LED round donwlight– 2" diameter Locations: Green Room	CCT: 3500K CRI: 90+ Output: 500 lm Watts: 7W Voltage: MVOLT Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to coordinate for compatible dimming control	GOTHAM - INCITO ICO 30/05 2AR (trim style) LSS 55D MVOLT UGZ TRW (accessories) Architect to verify white flange finish Alternate manufacturers: Lucifer USAI

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL12	Recessed mounted lensed LED 2'x2' Locations: Ticketing	CCT: 3000K CRI: 90+ Output: 3155lm Watts: 31.6 Voltage: UNV Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to coordinate for compatible dimming control	PINNACLE LF22A-30MO-G-UNV-1D-W-(options) Contractor to coordinate mounting with ceiling type; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Axis Mark Lighting
TL13	Recessed nominal 1 ½" wide lensed LED linear – 20'long Locations: Green Room	CCT: 3000K CRI: 90 Output: 421lm /ft Watts: 5.2W /ft Voltage: UNV Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to coordinate for compatible dimming control	SELUX L36-1A20-30-LW-(mounting)-20-WH-UNV-DIM-C9 Contractor to coordinate fixture mounting; Architect to verify white finish; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Axis Mark Lighting

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL14	Recess mounted LED wallwash – 4" diameter Location: Theater	CCT: White 3000K CRI: 90+ Output: 1500 lm Watts: 26.3W Voltage: MVOLT Dimming Protocol: eldoLED Power Drive DMX Control Protocol: DMX	Gotham EVO WW 30/15 4AR LSS MVOLT EDBX (flange finish) CRI90 Architect to select flange finish; 1% dimming; eldoLED Power Drive DMX with RDM (remote device management); Contractor to coordinate mounting Alternate manufacturers: Edison Price Zumtobel
TL15	Recessed lensed LED linear - 4" wide Locations: Ticket Office	CCT: 3000K CRI: 90+ Output: 638 lm/ft. Watts: 7.3 W/ft Voltage: 120-227V Dimming Protocol: 0-10V Control Protocol: Electrical Engineer to coordinate for compatible dimming control	SELUX L10 1A30 30 LW (mounting) 10 WH UNV DIM C9 Architect to verify white finish; Contractor to coordinate length and mounting detail with ceiling condition; Electrical Engineer to coordinate 0-10V diming with compatible dimming module and interface for control system being provided Alternate manufacturers: Axis Mark Lighting

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TL16	Wall mounted picture light – 1.12" diameter Locations: Ticket Office Window	CCT: 3000K CRI: 80+ Output: 493 lm/ft. Watts: 6.2 W/ft Voltage: Electrical Engineer to confirm Dimming Protocol: non-dim Control Protocol: TBD	VODE 107-RR 01 10' 60 WA 18" 2R AE (voltage) 0 Z SO 30 1 0 (finish) 0 Architect to specify finish; Contractor to coordinate wall mounting detail; Alternate manufacturers: Axis Mark Lighting

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
Theater – Site Lighting			
TLX1	Pole mounted LED pedestrian light attached to 4" square pole – overall 10' height Location: Theater Surroundings (Campus Standard Fixture)	CCT: White 4000K CRI: 83 Output: 2,415 lm Watts: 30W Voltage: Electrical Engineer to confirm Dimming Protocol: Electrical Engineer to coordinate Control Protocol: Electrical Engineer to coordinate	RAB ALED26N – BLACK Pole: PS4-11-10D2 Type IV distribution (forward throw); finish to match existing fixture; Architect has confirmed black finish; Contractor must coordinate fixture to match existing light pole Alternate manufacturers: N/A
TLX1A	Back to back pole mounted double LED pedestrian light attached to 4" square pole – overall 10' height Location: Theater Surroundings (Campus Standard Fixture)	CCT: White 4000K CRI: 83 Output: 2,415 lm per head Watts: 30W per head Voltage: Electrical Engineer to confirm Dimming Protocol: Electrical Engineer to coordinate Control Protocol: Electrical Engineer to coordinate	RAB (2) ALED26N – BLACK Pole: PS4-11-10D2 Type IV distribution (forward throw); finish to match existing fixture; Architect has confirmed black finish; Contractor must coordinate fixture to match existing light pole to match adjacent light poles except for double head mounting Alternate manufacturers: N/A

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

PART 4 LUMINAIRE SCHEDULE

TYPE	*DESCRIPTION*	*LAMP / ELECTRICAL*	*MANUFACTURER / CATALOG #*
TLX2	Exterior wet location surface mounted wall LED sconce, direct light with Type IV distribution, fixture dimensions nominally 8"L x 8" H x 3.75" D Location: Entry/exit doors	CCT: White 4000K CRI: 85+ Output: 1598 lm Watts: 30W Voltage: 120-277V Dimming Protocol: non-dim Control Protocol:	BEGA 33 242 (finish) – K4 TYPE IV distribution with back light control; Architect to specify finish and verify 4000K color temperature Alternate manufacturers: ERCO PRISMA
TLX3	Recessed mounted LED Step Light Location: Loading Dock Stairs	CCT: White 4000K CRI: 85+ Output: 16 lm Watts: 10.1W Voltage: 120-277V Dimming Protocol: non-dim Control Protocol:	BEGA 22 197 (finish) – K4 Architect and Contractor to coordinate mounting location and detail; Architect to select finish and to verify 4000K Alternate manufacturers: BK Lighting PRISMA

END OF SECTION

Notes:
1. Electrical Engineer to confirm voltages.
2. Contractor shall verify all catalog codes withdrawn and written descriptions.
3. Architect to verify all fixture finishes.
4. Architect to verify ceiling all ceiling materials and thicknesses for fixture trim coordination. Thick ceilings (greater than ¾") may require modifications to fixtures.

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PART 1 - GENERAL

1.1 SUMMARY

A. This section includes dimming and control systems for performance lighting, concert lighting, work lighting, and house lighting.

B. CT DAS Warranty

1. Refer to section 01 78 30 for specific information on warranty information

C. Section Includes:

1. Work in the following spaces:
    a. Proscenium Theatre
2. Systems:
    a. DMX Driven Relay Panels
    b. Electronics Racks
    c. Control Consoles and Accessories
    d. House/Work Light Control Systems
    e. Data Communications Devices
    f. Performance Lighting Distribution and Control Faceplates
3. Provision of materials, components, modifications, assemblies, equipment and services as specified herein. These include, but are not limited to:
    a. Verification of site dimensions and conditions
    b. Submittals as required by the Contract Documents
    c. Engineering of equipment and systems as required by the Contract Documents
    d. Manufacture of equipment and systems as required by the Contract Documents
    e. Coordination with the System Integrator as required by the Contract Documents
    f. Scheduling, sequencing and coordination with other trades
    g. Installation and supervision for equipment and systems specified herein and elsewhere in the Contract Documents
    h. Testing and demonstration of equipment and systems as specified herein and elsewhere in the Contract Documents.

D. Related Sections:

1. Division 11: Equipment:
    a. Section 11 61 33: Theatrical Rigging
    b. Section 11 61 91: Theatrical Lighting Instruments and Accessories
    c. Division 26: Electrical
    d. Section 26 51 12: System Integration
    e. Section 26 51 13: Architectural Luminaires, Lamps, Ballasts

1.2 REFERENCES

A. Reference Standards:

1. National Fire Protection Association (NFPA) Publication: National Electrical Code, NFPA70
2. Underwriters Laboratories Standards:
    a. UL498, Electrical Attachment Plugs and Receptacles
    b. UL508, Electrical Industrial Control Equipment
    c. UL891, Dead-front Electrical Switchboards
    d. UL1573, Stage and Studio Lighting Units
1. United States Institute for Theatre Technology Standard: DMX512-A (2008), Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories
2. ANSI Standards
    a. ANSI E1.11 - 2008 (R2013) Entertainment Technology - USITT DMX512-A, Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories
    b. E1.17-2006 Entertainment Technology - Architecture for Control Networks
    c. E1.20-2006 Entertainment technology – Remote Device Management
    d. E1.20-2-2009 Entertainment Technology – Recommended Practice for Installing Control Cables
    e. E1.30-7-2009, EP129 - Allocation of Internet Protocol Version 4 Addresses to ACN Hosts
    f. E1.31-2009 Entertainment Technology - Lightweight streaming protocol for transport of DMX512 using ACN
3. Institute of Electrical and Electronics Engineers, Inc.:
    a. Standard: 802.3
    b. Standard: 802.11 b or g

4. National Electric Code
5. American National Standards Institute
6. International Building Code

1.3 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. DMX: Digital Multiplexing

C. NEC: National Electric Code

D. UL: Underwriters Laboratories, Inc.

E. USITT: United States Institute for Theatre Technology, Inc.

F. ESTA: Entertainment Services and Technology Association

G. FURNISH: Deliver and hand over to others for installation

H. INSTALL: Set in place and connect

I. PROVIDE: Furnish and Install

1.4 SUBSTITUTIONS

A. Substitutions, changes, or deletions from the plans and Specifications will not be allowed without the prior written approval of the Architect.
   1. Substitution proposals from manufacturers not listed herein shall be accompanied by sufficient catalogue data, specifications, technical information, shop drawings, and samples to prove equivalence or superiority of the proposed substitution.
   2. If any additional wiring or conduit is required due to an accepted substitution, the Dimming System Manufacturer shall contract with the General Contractor to perform this additional work at no cost to the Owner.

B. Proposals to submit bids for specific equipment by manufacturers listed herein which have been modified or improved will be considered, provided they are submitted to the Architect for approval.
   1. Proposals shall be accompanied by sufficient catalog data, specifications, technical information, and samples to permit proper evaluation.

C. All questions regarding these plans and Specifications shall be referred to the Architect.

1.5 SUBMITTALS WITH BIDS

A. In addition to the submittals required under the General Conditions of these Specifications, all bidders shall submit with their bids the following:

1. Current specifications and catalog cuts for the proposed equipment.
2. Current specifications and catalog cuts for the house light control system.
3. Current specifications and catalog cuts for the stage lighting control console.
4. The specifications and catalog cuts furnished shall be those which were in effect on the date of issue of this Specification.
5. Documentation demonstrating the existence of a seven (7) day, twenty-four (24) hour field service organization staffed by more than one (1) full time factory-trained service technician capable of making field service repair visits.
    a. Manufacturer's representatives and/or outside technicians cannot be listed as members of the field service organization.
6. A list of at least ten (10) systems of similar scope and size which have been in service for at one (1) year.
7. A schedule with the following time estimates:
    a. Length of time required to prepare shop drawings.
    b. Length of time required to supply all equipment.

1.6 SUBMITTALS

A. Provide submittals in accordance with General and Special Conditions. Submit submittals in a timely manner, allowing sufficient time for adequate review and possible resubmittal without jeopardizing the project schedule.

B. Shop Drawings:

1. Submit shop drawings within forty business (40) days of award of contract, unless otherwise indicated in Division 1.
2. Drawings for fabrication and installation of all products; Drawings will show all information necessary to explain fully the design features, appearance, function, fabrication, installation and use of system components in all phases of operation.
    a. Show materials, thickness, gauges
3. Provide relay panel schedules based on the current information from the contract documents.
4. Fabrication, Installation, and Erection shall not commence until shop drawings have been approved by the Architect and the Theatre Consultant.
5. Submittal shall be drawn in an 11 inch by 17 inch format.

6. All sheets in the submittal shall be of the same size.
7. Submittal shall include a title sheet listing all sheets in the submittal.
8. Submittal shall include a complete bill of materials showing all items being supplied by the manufacturer and or supplier.

C. Commissioning Documentation:

1. Certificates from the manufacturer's field engineer stating the installed system is operating properly and complies with manufacturer's recommendations
2. Ethernet cable run certification
3. Schedule of all tested and certified Ethernet cable run lengths

D. Record Drawings and Maintenance Manuals:

1. Operations and Maintenance Manuals (O&M) shall include:
    a. As-built drawings
    b. Final relay and associated panel schedules including DMX, sACN and EDMX addressing
    c. Contact information for pertinent manufacturers
    d. Safety and Operational Instructions
    e. Complete parts and subassembly list
    f. Software version information
    g. Wiring diagrams and termination schedules
    h. Periodic Maintenance Schedule
    i. A maintenance procedure for finishes
    j. Certificates of compliance with applicable codes
    k. Records of final testing and log
    l. Spare parts list and source information
    m. Warranty documentation
    n. Provide the above in universal electronic format files; pdf file type is preferred, as full size printable sheets. Submit files on standard pc format CD clearly labeled including project name, project architect, theatre consultant, contractor name, date of submittal.
2. Bind all O&M documentation separate from general building sections so they can be turned over to the users after approval.
3. Provide draft copy of completed manuals for review to the Theatre Consultant before the start of commissioning.

4. Include diagrams depicting the system layout and interconnections. Reduced size, 11 by 17 inch preferred.
5. Provide three (3) copies of operation manuals
6. Provide two (2) copies of each system configuration on CD (Lighting Console, Nodes, Relays).

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: A firm who has been continuously engaged in the production of theatrical lighting and control equipment for at least fifteen (15) years and in the manufacture of theatrical dimming systems for a minimum of ten (10) years.
2. Installer: Skilled technicians who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and best industry practices for the proper installation of the work
3. The following are Theatre Lighting Controls Dealers:

4 Wall Lighting
Contact: Bill Groener
35 State St.
Moonachie, NJ 07074
(201) 329-9878

Barbizon Lighting
Contact: John Gebbie
456 West 55th Street
New York, NY 10019
(212) 586-1620

Supertech, Inc.
Contact: Steve Hamelin
22 North Plains Industrial Road, Suite #4
Wallingford, CT
(203) 294-9400

Vincent Lighting Systems
Contact: Paul Vincent
6161 Cochran Rd Suite D
Solon, OH 44139
(216) 475-7600

B. Manufacturer shall provide a twenty-four (24) hour emergency service phone line.

1. A field service engineer shall respond to an emergency call on this line within thirty (30) minutes.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment and controls securely wrapped in factory fabricated wooden or fiberboard containers.

B. Handle equipment and controls carefully to prevent breakage, denting and scoring finish. Do not install damaged equipment and controls; replace and return damaged units to equipment manufacturer.

C. Acceptance at Site: Contractor shall accept and inventory all equipment upon delivery and provide copies of the inventory to the architect.

D. Storage and Protection: Store equipment in a secure, environmentally controlled location. Place no equipment until that location is substantially completed, free from construction dust, and “broom clean.” Store in original cartons and protect from dirt, physical damage, weather, and construction traffic.

E. The Dimming System Manufacturer shall coordinate delivery of all equipment with the Electrical Contractor.

1. If required by the Electrical Contractor, Dimming system equipment shall be delivered in a minimum of three (3) separate shipments based on Electrical Contractor requirements.

2. Minimum shipment increments shall include:

a. Shipment #1: All items in which conduit is terminated. This shall include relay cabinets, line voltage and control station back boxes.

i. Shipment 1 shall occur eight (8) weeks after receiving approved shop drawings.

b. Shipment #2: All items in which wiring is terminated. This shall include control station faceplates, etc.

c. Shipment #3: All items that are not required until the system activation by the Dimming System Manufacturer's field service representative. This shall include electronics modules, control consoles, monitors, printer, focus remote, cables, portable control stations, etc.

d. Dimming System Manufacturer shall schedule shipment #3 based on discussions with the Owner.

e. If shipment #3 items are delivered to the job site prior to the agreed upon schedule, the Dimming System Manufacturer shall be responsible for providing storage for these items until they are required on the job site.

1.9 PROJECT CONDITIONS

A. Field Measurements: Contractor is to verify all dimensions as they relate to requirements of the specification and manufacturer's requirements and is to notify the Owner's Representative of any variations, which would affect the installation and safe operation of the systems.

1.10 SCHEDULING AND SEQUENCING

A. Provide a project schedule at time of contract award, indicating critical path for installation of these systems and coordination with other trades.

B. Coordinate with Electrical Contractor for the provision of conduit for electrical power and control wiring.

1.11 WARRANTY

A. Refer to section 01 78 30 for specific information on warranty information

B. Special Warranty:

1. Provide five (5) year warranty for relay panels
2. Provide three (3) year warranty for UPS devices
3. Provide warranty for systems and equipment to be free of defective components, faulty workmanship, and improper adjustment for a period of two (2) years from the date of substantial completion or acceptance by the Owner, whichever is later. Paint and exterior finishes are excluded. Replace items showing evidence of defective materials or workmanship (including installation workmanship) within thirty (30) days after notification. Make replacements without cost to the Owner.
4. Rectify conditions that might present a hazard to human life, well-being, or property within forty-eight (48) hours of notification.

C. Designate warranties on manufactured equipment to the Owner to commence on the date of system acceptance.

1.12 COMMISSIONING

A. Provide demonstration and testing of systems described in this section.

1.13 MAINTENANCE

A. Maintenance Service: Provide maintenance service for a period of two (2) years after final acceptance of the installation. This service shall cover parts and labor. This service consists of at least two (2) half-yearly visits to the site for checking and adjusting of equipment. Perform the first visit six (6) months after the system has been accepted.

B. Continuing Service Proposal: At time of bid, provide a separate proposal for continuing annual service visits to the installation for inspection and maintenance of the supplied systems.

1. Provide a proposal for the first visit to occur two (2) years after the date of hand-over and to continue for five (5) years after the date of commencement.
2. The proposal shall remain valid and extended until the date of hand-over, at which time the Owner may accept or reject the proposal without prejudice.
3. Warranty site visits, as specified in the Contract Documents, are specifically excluded from the Continuing Service Proposal.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide the dimming systems from components (except where otherwise stated) that are the products of one of the following manufacturers:

1. Electronic Theatre Controls, Inc., Middleton, WI (608) 831-4116
2. MA Lighting North America, A.C.T Lighting East, Hackensack NJ (201) 996-0884
3. Pathway Connectivity, Calgary AB (403) 243-8110
4. Strand Lighting, Inc., Dallas, TX (214) 647-7880

2.2 CONTROL CONSOLES

A. General:

1. Control consoles to be provided by same manufacturer as dimming and control system.
2. Provide software current at time of installation.
    a. Provide a minimum two (2) year subscription to update all performance lighting console software such as fixture libraries, visualization software, and related lighting paperwork.
3. Console shall be configured to be a node on the lighting network and shall be ACN compatible.
4. Software Features:
    a. Capacity to display the following screens
    b. Stage (live) - Levels currently active on stage
    c. Preview (blind) - Levels recorded in a preset
    d. Softpatch - Patching information

e. Setup configuration - Basic operating parameters
f. Disk read, write and format
g. Clear show
h. Setup Parameters
i. Default Fade Time
j. Channel configuration
k. Hardware configuration
l. Print Functions:
    i. Stage Display
    ii. Cues
    iii. Submasters
    iv. Patch
m. Patching:
    i. Proportional patching
n. Recording
o. Channel list constructed with AND and THROUGH functions
p. Proportional adjustment of current channel list with level wheel
q. Setting of levels with AT function
r. Release of channel list without modification
s. Recording of stage or blind settings
t. Cue numbers between 000.1 to 999.9
u. Non-sequential recording
v. Cue time fades of 1 to 99 seconds
w. Split fade up and down times
x. Cue linking allowing cues to automatically follow each other
y. Link delay time

5. Playback:
    a. Pairs simultaneously timed cross fades, pile-on fades, and split fades
    b. Last action within each fader pair
    c. Highest level between fader pairs
    d. Capacity to override, halt, or release halted fades

e. Discrete overriding of each half of a fader pair

6. Submasters:
   a. Totals specified herein shall be for physical faders. Digital “soft” submasters or pages of submasters shall not count to the total specified.
   b. Submasters are overlapping in a highest takes precedence fashion.
   c. Each submaster has a bump button which forces channels assigned to that submaster to their recorded level.
   d. Submasters are recorded live or blind.
   e. Proportional control of assigned levels
   f. Capacity to build cues from submasters
7. Effects package including:
   a. Effects built from submasters
   b. Variable one (1) to six (6) part chase
   c. Level and rate control of chase
8. On-line help information

B. Performance Lighting Console
   1. Minimum Basic Capacities:
      a. 4,000 outputs
      b. Ten thousand (10,000) control channels
      c. Ten thousand (10,000) cue memory capacity
      d. Twenty (20) submasters
         i. Provide fader wings to meet this total
      e. Current fixture library
   2. Hardware Features:
      a. Two (2) black 21-inch local LCD flat panel touch screen displays matched to the console specifications
      b. One (1) remote focus port
      c. One (1) Ethernet port for remote video and Designer’s remote
      d. Four (4) USB ports
      e. Midi/SMPTE Time Code
      f. Operating software stored in upgradeable, internal non-volatile memory
      g. Show data storage in battery backed up random access memory

h. One (1) internal hard drive for library storage

i. Extended numeric keypad for entering DMX address, channel, submaster, preset, level, time and link instructions

j. Display keypad to provide access to display settings

k. One alpha-numeric keyboard for notating cue information

l. Level wheel for proportional intensity control over user selectable channels

m. Two (2) electronically timed cross faders with manual override, each with a fade time status display, HOLD, CLEAR, GO BACK and GO functions

n. Proportional Grand master

o. Moving light attribute encoders and built-in support for standard moving lights and color scrollers

p. Receptacles for plug-in control cables

q. AC power cable and a set of 25'-0" control cables with connectors

3. Acceptable products:

a. Electronic Theater Controls – Ion

b. Strand Lighting – Neo

c. MA Lighting – Dot2 core

C. Console Accessories:

1. Refer to the schedule herein for quantities

a. Remote Focus Unit:

i. Provide portable units capable of calling up relays channels, cues and submasters.

ii. Provide console with wireless remote focus unit

iii. Provide touchpad or PDA device for the wireless portable remote control. Device shall be capable of calling up DMX addresses, channels, cues and submasters.

iv. Basis of Design for wireless unit: iPad touch-screen tablet.

v. Provide dual band wireless access point(s) to support portable wireless unit.

vi. Provide spare battery and charger for each handheld portable.

b. Remote Video:

i. Provide full-featured Ethernet node.

ii. Provide black 19-inch flat panel LCD monitors meeting console manufacturer’s specifications.

iii. Provide a complete set of 10 foot cables.

c. Console Desk:

i. Provide castered console stand suitable for use at lighting control room observation window.

ii. Provide one (1) monitor arm for each local console monitor. Design monitor arm to allow the easy repositioning of the monitors above the console.

d. Dust Covers:

i. Provide custom cloth dust covers made of heavy weight IFR muslin for each console and each video displays.

ii. Provide heavy duty water proof covers with soft lining for consoles.

e. Back-up data storage:

i. Provide two (2) eight-gigabyte USB keys per console.

f. Uninterruptible Power Supply

i. Provide convection cooled UPS

2.3 HOUSE / WORK LIGHT CONTROL SYSTEM

A. General:

1. Provide an integrated House/Work Light Control system. The system is capable of controlling performance, concert, and house lighting and work lighting relays through local and master control stations.
2. Provide rack mounted Ethernet to DMX nodes to control LED house lights.
   a. Count DMX addressing requirements for relays and fixtures using the finest resolution for the models specified. Provide processors with capacity for the total of all DMX assignments.
   b. Review the electrical drawings for quantities of DMX addresses and provide processors capable of controlling LEDs to their finest resolution.
   c. DMX scheme shall assign universes so as to leave a minimum of two (2) DMX universes free for future expansion.
3. House/Work Light Controls and Control Console have simultaneous “pile on” control.
4. Provide relays and circuit breakers based on zone designations. Relays shall not be ganged on individual circuit breakers.
5. Provide equipment and services to connect to the building management system through BACnet.
6. Provide equipment and services to connect to the fire alarm system

B. Standard Operating Features:

1. Control system allows cross fading between presets within each of multiple rooms.
2. Presets can mirror between stations.
3. System parameters are user configurable. These parameters include but are not limited to current date, current time, high level limit, control station name, preset names, presets, mirror designation, lockout modes, assignments per channel, preset master names, station numbers, channel levels, and station names.
4. System accepts dry closures from external sources. Closures shall be momentary alternate action turning channels or presets on or off.
5. Fade times on each preset are adjustable from 0 - 999 seconds.
6. Preset masters are available to control groups of presets throughout the system.
7. Preset masters shall also provide “template” ability whereby station activation or control parameters maybe changed.
8. System provides disk storage of configuration and lighting data.
9. Provide Architectural lighting program to owner for future changes to system configuration.

C. Pushbutton Stations:

1. Provide Pushbutton Stations with the following minimum capabilities and equipment:
    a. Each Pushbutton may be configured to control a single channel or a single preset as required.
    b. Each Pushbutton may be configured either to toggle a preset or channel on and off or to initiate a crossfade to another preset as required.
    c. Each Pushbutton may be configured to allow resetting of the channel or preset intensity by holding the pushbutton until the preset or channel fades to the desired level and releasing the pushbutton to store the new level.
    d. Faceplate signage is screened as per Contract Documents. Each pushbutton station may be configured to control multiple channels or presets as required by the different states for which the system is configured.
    e. Station shall fit into a standard single gang wall box for recessed installation.
    f. Provide painted steel backbox sized to faceplate dimensions for surface installation.
    g. Provide LED indicators programmable as locator lights, station active pilot lights, or station enabled pilot lights.

D. Houselight/ Worklight Control Panel (Faceplate HLM-7 and HLM7-P):

1. Provide Houselight Control Station with the following minimum capabilities and equipment:

a. The panel shall contain (12) pushbuttons labeled "House Full," "House Half", "House Out," "Preset 1," "Preset 2," "Show," "Work," "Reh," "Night," "Manual," "Record," and "Off."

b. Additionally, the panel shall contain six (6) sliders plus one (1) master.

i. Fader Assignments shall be made during commissioning.

c. The panel shall provide up to 128 presets.

d. Access to all addresses in the systems shall be provided by the PC-based set up program.

e. Station shall be able to address individual addresses within a preset and modify levels and fade times.

f. Multiple control stations shall mimic and control shall be last action takes precedence with lockout capability.

g. Provide wall mounted panels to fit standard gang back box as indicated on the Drawings.

E. Stage Manager’s Console Stations (portable Consolette HLM7-P):

1. Provide portable panel in a table top consolette with 25 foot control cable for each space with a dedicated house worklight control system.

2. Provide momentary action illuminated push buttons wired to closure stations to interface to house/work light control system.

3. Large backlit push buttons as shown on Drawings shall activate preset master states.

4. All pushbuttons shall stay illuminated while in dedicated “state.”

F. Control Station Material and Finish:

1. Material: 1/8 inch aluminum.

2. Finish: “Black” or “Custom” as indicated on the Drawings.

a. Black finish: 120 grit, horizontally brushed black anodized.

b. Special finish: Powder coat painted finish.

3. Legends: Engraved and paint filled as shown or as directed.

4. Reinforce faceplate as needed to minimize deflection.

G. Configure the system to provide no delay time between the toggle "on" position and the illumination of the lighting fixture and the reporting back to the station.

H. Acceptable Products: Subject to the above requirements, provide one of the following products:

1. Electronic Theatre Controls Unison/Paradigm
2. Strand Lighting Vision Net
3. Pathway Connectivity Choreo

2.4 DMX DRIVEN RELAY PANELS

A. Control Features:

1. Standard control format is DMX-512 over Ethernet
2. Contains diagnostics
3. Hold relay positions in the event of a control interruption.

B. Relays:

1. Provide relays and circuit breakers based on zone designations.
2. Relays shall not be ganged on individual circuit breakers.

C. Accessories for use as emergency lighting panel

1. Provide power loss sensing device, by-pass option, UPS battery backup and other accessories to configure standard relay panel for use on a normal/emergency feed.
2. At time of power loss relay panel control module shall switch all relays within that panel on.
3. Refer to the electrical drawings for relay panel assignments to emergency lighting use.

D. Acceptable Products:

1. Electronic Theatre Controls, Echo Relay Panels
2. Lyntec, LC Series DMX Lighting Control
3. Strand Lighting, Contact Relay Panels

2.5 DATA COMMUNICATIONS

A. Provide a fully functioning Performance lighting Ethernet system. Install the system in conformance with the latest ESTA and IEEE 802.3 standards and the control console manufacturer's requirements.

B. Provide a personal laptop computer, running the latest version of Microsoft Windows, with a minimum 14 inch screen for network lighting control system management. Computer shall meet or exceed recommended system specifications for the specified operating system, and a minimum 60GB hard drive. Computer must be able to monitor network activity in real time.

1. Provide latest versions of software listed below to allow user to configure network hardware, house worklight system and hardware.
2. Software
    a. Manufacturer's network switch and node configuration application and project file
    b. Manufacturer's architectural lighting configuration application and project file
    c. Manufacturer's relay configuration application and project file.
    d. Microsoft Windows
    e. Microsoft Office
    f. Lightwright
    g. Console off-line editing software
    h. Provide copy of above software on CD or DVD with one institutional license (6 users)
3. Provide network diagnostic tools (software) to enable users to view network activity and diagnose data problems.
4. Power filtration/line regulation/battery backup with the following minimum capacities:
    a. Input voltage < 132 V AC
    b. Output voltage 115 V AC $\pm$ 5 percent
    c. Transfer voltage 103 V AC
    d. Surge energy 240 J
    e. Surge current 6500 A peak
    f. Surge response time 0 ns (instantaneous)
    g. Noise filtration, full time EMI/RFI suppression, 100 kHz to 10 MHz, > 60 dB
    h. Audible low battery signal
    i. Minimum of ten (10) minutes back-up time

C. Provide Cat-5e green jacketed cable to identify the lighting control network.

D. Coordinate the wireless Ethernet protocols with other areas of theatrical production (Sound, Rigging and Automation, and Administration) to ensure that the theatrical lighting system has its own dedicated secured channel and does not broadcast SSID information that would allow the system to be compromised. Set up MAC address filtering if nearby networks require it.

E. Control (Aux) Rack

1. Provide standard 19 inch control rack(s) with sufficient space to accept devices as shown on the drawings.
2. Control Rack Accessories
    a. 2U drawer
    b. Locking door
    c. Regressing brackets to permit the door to close with connectors patched to devices.
    d. 10U of spare rack space
    e. Blank panels to fill all spaces

F. Ethernet Switches/Patch Panels:

1. Provide switches and patch panels of a high quality from a company with five or more years of experience manufacturing this equipment.
2. All Ethernet switches shall be Power-over-Ethernet, dual speed units capable of operating standard and fast Ethernet protocols.
3. Label switches and patch panels with the locations of the field boxes and as labeled in the box schedules.
4. Provide proper quantity of Category 5 patch cables to patch all field devices to hubs/switches.
5. All wireless switches must comply with latest IEEE 802.3 b/g standards and are to be installed using best industry practices.
6. Provide web browsable switches that can be accessed through any commercially available web browser.
7. Provide rack mounted power filtration/line regulation/battery backup unit (as specified herein) for each hub/switch.
8. Acceptable switch manufacturers:
    a. Cisco Systems – 170 West Tasman Drive, San Jose, CA
    b. Dell Inc. - One Dell Way, Round Rock, TX
    c. Hewlett-Packard Company - 3000 Hanover Street, Palo Alto, CA

G. Ethernet Nodes:

1. Provide the latest products available from the control console manufacturer at the time of installation.
2. Provide rack mounted four port node in aux rack for DMX output.
3. Provide control cable packages as listed in the schedule in Part 3 of this section.

H. Manufacturers:

1. Electronic Theatre Controls, Inc., Net3
2. Pathway Connectivity Pathport
3. Strand Lighting, Inc., Shownet

2.6 DISTRIBUTION AND CONTROL FACEPLATES AND BACK BOXES

A. Provide line voltage and control faceplates and back boxes as shown in the TL-series drawings.

B. General:

1. For surface mounted conditions faceplate and back box dimensions are equal.
2. Remove sharp edges and burrs on faceplates.
3. In all cases faceplate screw color is to match faceplate color.

C. Distribution (Line Voltage) Faceplates:

1. Material: Minimum 14-gauge steel.
2. Finish: “Black” or “Custom” as indicated on the Drawings.
    a. Black finish: Powder coat flat black enamel.
    b. Special finish: Powder coat painted finish to match Architect’s sample.
3. Provide terminal strips as needed for connection of wiring within pigtail boxes.
4. Reinforce faceplates as needed where deflection may occur under heavy use.
5. Provide a removable label on the faceplate designating the box number as shown in the drawings.
6. Label each faceplate with circuit numbers as shown on the Drawings and Schedules.
    a. Material: 1/8 inch black lamacoid.
    b. Finish: Black with non-yellowing white fill.
    c. Engraving: 1/2 inch high characters with non-yellowing white fill.
    d. Attach labels to the faceplate with appropriate adhesive and rivet to faceplates.
7. Label the inside back of each box with an arrow indicating the "up" position.

8. Label the outside top of each box with a removable OSHA yellow sticker with a minimum of 1-inch high lettering indicating the "up" position.
9. Fill unused pre-drilled mounting holes.
10. Receptacles
    a. Receptacles shall be UL listed
    b. Receptacles shall be black
    c. 20amp 120v 19-Pin multi connectors
    d. 15amp 120v NEMA L5-15
    e. 20amp 120v NEMA 5-20

D. Control Faceplates:
1. Material: 1/8 inch aluminum.
2. Finish: “Black” or “Custom” as indicated on the Drawings.
    a. Black finish: 120 grit, horizontally brushed black anodized.
    b. Special finish: Powder coat painted finish to match Architect’s sample.
3. Reinforce faceplate as needed to minimize deflection.
4. Legends: Engraved and paint filled as shown or as directed.
5. Provide a removable label on the faceplate designating the box number as shown in the drawings.
6. Faceplate shall fit into standard sized gang wall box for recessed installation.
7. Provide painted steel backbox sized to faceplate dimensions for surface installation.

E. Acceptable Manufacturers:
1. Electronic Theatre Controls
2. Strand Lighting
3. TMB Associates
4. Lex Products
5. Union Connector

2.7 ACCESSORIES

A. Provide two (2) copies of associated manuals.

B. Configuration Documentation:
1. Provide two (2) copies of each system configuration on the specified PC and USB key.

2.8 SUPPLEMENTARY

A. Provide equipment and hardware in addition to the items specified previously that are necessary to provide a fully working system in conformance with the intent of the Contract Documents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where performance dimming and controls are to be installed and to verify that conditions are satisfactory for installation and comply with manufacturer's requirements and those specified in this section.

B. Lighting control electronics shall not be installed in rooms where the interior finishes are not complete.

1. Control rooms and relay rooms shall be broom clean and free of debris.
2. Do not proceed with installation until unsatisfactory conditions have been corrected.

C. Examine drawings and confirm that number, size, and location of conduits are adequate for proposed system.

3.2 INSTALLATION

A. Install performance lighting and controls where shown, in accordance with manufacturer's written instructions and with recognized industry practice to ensure that performance lighting equipment complies with applicable requirements of NEC and UL standards and with the applicable portions of NECA's "Standard of Installation."

B. All load circuit conductors shall be continuous from the relay cabinet the back box without splices or connectors.

C. All data wiring shall be continuous from termination point to termination point. No splices or connectors allowed.

D. Provide programming coordination with other manufacturers field technicians to implement and commission connections to the BACnet and fire alarm systems.

1. BACnet programming shall include all house light and work light zones within the auditorium, stage and backstage areas.
2. Review the electrical drawings for the zone information.

3.3 FIELD QUALITY CONTROL

A. Provide or facilitate the following tests or inspections. Correct deficiencies and retest deficient items.

B. Visual and Mechanical Inspections: Include the following:

1. Inspect each outlet, relay and other loose items of equipment for defects, finish failure, corrosion, physical damage, labeling, and nameplate.
2. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's instructions or routine functional operation.
3. Check tightness of electrical connections with torque wrench calibrated within the previous six (6) months. Use manufacturer's recommended torque values.
4. Verify proper protective device setting and fuse types and ratings.

C. Electrical Tests: Perform according to manufacturer's instructions. Exercise caution testing devices containing solid state components.

1. Operational and continuity tests of dimming circuits. Perform an outlet by outlet operational test of the dimming and relay circuits to determine proper wiring and exact correspondence between the relay numbers and the outlet labels.
2. Operational tests of Ethernet runs: Test each Ethernet wiring run for proper operation in conformance with the IEEE standard. Document the length of each run.

D. Manufacturer's Field Service:

1. Provide the services of a qualified service representative, employed regularly and full time by the manufacturer of the control system(s), to check the installation of the control system(s) and ensure its proper operation. Do not energize any part of the control system until their check is complete and the service representative is present to observe the turn-on procedure.
2. Provide manufacturer's technician to configure house/work lighting control system as directed prior to system commissioning. One (1) set of changes to the initial operating configuration may be required subsequent to commissioning. One (1) set of changes will be required following acceptance.

E. System Commissioning:

1. Upon completing installation, other tests, and manufacturer's check-out, schedule an inspection and operating test with the Architect and Theatre Consultant. Facilitate such tests as may be required to ensure that all equipment is in compliance with the intent of the specification.

2. Upon completion of the installation, and before scheduling the system inspection with the Architect, Theatre Consultant and Architectural Lighting Designer, the Electrical Contractor shall confirm the following in writing:
    a. Theatrical load circuits have been tested and are operational.
    b. Data circuits have been tested and are operational.
    c. Architectural control stations installed and are operational.
    d. Architectural lighting loads are terminated, operational and assigned addresses per the contract documents.
    e. Loose equipment is on site and located in the control room for each performance space. Equipment should be secured within these control rooms to prevent theft, or damage from construction debris.
    f. If any of the above items are found to be incomplete after receipt of notification, the Electrical Contractor shall reimburse expenses including labor, travel, hotel and meals.
3. Comply with the following conditions required for commissioning:
    a. Provide documentation to Theatre Consultant certifying all Ethernet outlets adhere to IEEE standards.
    b. Loose equipment provided under this section to be on site and available for testing.
    c. All architectural lighting fixtures wired to the dimming system shall be installed and lamped.
    d. Provide full and uninterrupted access to stage, auditorium, and technical areas required for commissioning tests. Blackouts of lighting will be required.
    e. Contractor's project representative to be present during tests as required.
    f. Provide Manufacturer technicians for final programming of all systems.
    g. Manufacturer's factory field technician to be present during tests and inspections.
    h. Provide personnel to operate equipment and perform adjustments as necessary.
    i. Provide access equipment as required.
    j. Provide four stations of professional quality radio communication and battery charging station.
        i. Provide a headset for each station.
4. Contractor is required to facilitate the Consultant/Architect commissioning of the Dimming and Control system. This commissioning will include but is not limited to the following items.
    a. Verify that loose and installed equipment quantities are as contracted.
    b. Inspect all system components individually for conformance to specification.

c. Test each branch circuit for operation, correct circuit identification, and proper arrangement of hot, neutral, and ground conductors.

d. Spot test selected branch circuits at maximum load.

e. Verify operation of all worklight and houselight fixtures. Test operation of all worklight and houselight control devices. Verify that logical operation of controls is as specified.

f. Verify operation of all portable control and portable display devices from all associated receptacle locations.

g. Using a DMX source, verify operation of DMX distribution network.

h. Confirm the proper operation of the lighting Ethernet system.

i. Review operation, maintenance, and instruction manuals. Review warranty certificate.

j. Confirm that user training has/will occur per specification.

3.4 CLEANING

A. Remove paint spatters and other spots, dirt, and debris.

B. Repair scratches and mars of finish to match original finish.

C. Clean devices and equipment internally and externally using methods and materials as recommended by manufacturers.

3.5 DEMONSTRATION AND INSTRUCTION

A. The manufacturer of the dimming system shall provide a minimum of forty (40) hours of training in the operation of the control console, architectural control system, and other related systems specified herein. These sessions shall consist of ten (10) – four (4) hour sessions at times separate from the check out of the systems. Training time to be arranged with the staff of the facility and shall take place over the first six (6) months after building acceptance. These training sessions cannot be completed consecutively and should be separated by no less than 1 month or as directed by users.

B. Provide video on CD of training for Owner's use in future training sessions.

3.7 CONTROL EQUIPMENT SCHEDULE

A. The following schedule includes off-the-shelf equipment for the lighting control system. Provide equipment and hardware in addition to the items specified that are necessary to provide a fully working system.

Item #	DESCRIPTION	Total
1	4000 output lighting console	**1**
2	Touch screen panels	**2**
3	Worklight	**2**
4	USB key	**5**
5	Cable set	**1**
6	UPS	**1**
7	Console Desk	**1**
8	Wireless Remote Focus Unit	**1**
9	Laptop System Control PC and software	**1**
10	2-port network nodes with clamps	**6**
11	10-foot network cable	**6**
12	Remote Video Node	**1**
13	Stage Manager's Console Stations (portable Consolette)	**1**

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 WORK INCLUDES

A. Control integration for architectural lighting control and LED luminaires
   1. Work in the following spaces:
   2. Provide integration of LED luminaires and controls to comply with the Contract Documents performance criteria.

B. If at any time during the project LED luminaires are substituted for non-LED luminaires, those LED luminaires shall be included in this specification and shall be subject to the criteria in this specification and the Contract Documents.

1.3 SUMMARY

A. Lighting & Control System Integrator (LCSI) is required to integrate lighting and controls provided under the following sections:
   1. 26 5105 - Luminaires
   2. 26 6111 – Theatrical Lighting Controls

B. Lighting and lighting control system integration in the following areas:
   1. Proscenium Theatre

1.4 REFERENCES

A. Reference Standards:
   1. National Fire Protection Association (NFPA) Publication: National Electrical Code, NFPA70
   2. Underwriters Laboratories Standards:
      a. UL498, Electrical Attachment Plugs and Receptacles
      b. UL508, Electrical Industrial Control Equipment
      c. UL1573, Stage and Studio Lighting Units

3. ANSI Standards
   a. E1.11 - 2008 (R2013) Entertainment Technology - USITT DMX512-A, Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories
   b. E1.17-2006 Entertainment Technology - Architecture for Control Networks
   c. E1.20-2006 Entertainment technology – Remote Device Management
   d. E1.20-2-2009 Entertainment Technology – Recommended Practice for Installing Control Cables
   e. E1.30-7-2009, EP129 - Allocation of Internet Protocol Version 4 Addresses to ACN Hosts
   f. E1.31-2009 Entertainment Technology - Lightweight streaming protocol for transport of DMX512 using ACN
4. National Electric Code
5. International Building Code

1.5 LIGHTING & CONTROL SYSTEM INTEGRATOR (LCSI) REQUIREMENTS:

A. The System Integrator shall be acknowledged in business as a Lighting Control Systems Integration Company, hereafter referred to as LCSI.

B. The LCSI Company shall employ full time technicians and project managers with experience in completing work of similar or greater size and scope.

C. The LCSI shall be a lighting system contractor who regularly engages in the furnishing, installation and servicing of systems of similar nature, size, scope and complexity.

D. The LCSI shall have maintained for the five (5) years preceding the bid date, a suitably staffed and equipped service organization which has continuously offered maintenance and repair services for the systems being provided.

E. The LCSI shall have on staff at least two (2) full-time manufacturer-certified field service technicians and have technical support and assistance accessible twenty-four (24) hours a day, seven (7) days a week. LCSI shall provide phone-based field service with a thirty-minute guaranteed response time.

F. The LCSI shall maintain for the duration of this contract all required business and professional licenses and insurance.

G. The LCSI shall demonstrate to the satisfaction of the Architect and Owner, through Submittals presented in accordance with the project timetable, that the LCSI meets all the above qualifications.

H. Requirements for Approval: LCSI who are not pre-approved and are seeking acceptance must submit the following information no later than ten (10) days prior to

bid date. Failure to submit any of the required information will automatically disqualify the contractor from consideration of approval.

1. Listing of five (5) equivalent installations including:
   a. Name, address, and current telephone number of Owner.
   b. Name, address, and current telephone number of Architect or Theatre Consultant associated with the installation.
   c. Scope of work of the installation including all sub-contractors and manufacturers.
2. Brief written description of the LCSI operation, including facilities, departments and key personnel.
3. Biographical information of the project manager and integration team members who will be assigned to this project should the contractor be successful.
4. A full and complete financial statement sufficient to determine financial viability.
5. A list of all sub-contractors who the LCSI proposes to use including their qualifications to perform the work.

1.6 SUBMITTALS

A. LCSI qualifications including the Project Manager's qualifications.

B. Review the Contract Documents and identify each LED system and its components including but not limited to the following:
   1. LED Luminaire
   2. Power Supply
   3. Control Signal Source
   4. Interface
   5. Wire and Cable
   6. Performance specifications for dimming curves, color rendering, and granularity
   7. RDM compliance and feasibility for remote adjustment of power supply profiles and DMX Addressing.
   8. Zoning and Circuitry

C. Review specific manufacturer dimming recommendations with the manufacturer's technicians.

D. Provide wiring diagrams for each LED system
   1. Include fixture, power supply, control source and interface
   2. Include emergency control for fixtures specified as emergency lighting
   3. Call out cable types
   4. Call out control addressing scheme
   5. Call out DMX runs based on zones.
   6. Coordinate control addressing scheme with the Lighting Control System Manufacturer and the Owner's Representatives.

E. Provide coordinated wiring diagrams

1. Locate power supplies on plan, RCP and elevation drawings
2. Confirm required power is provided by the Electrical Contractor
3. Coordinate access to power supplies with the General Contractor
4. Estimate wire and cable lengths
5. Review the wiring diagram with the Electrical Contractor and provide recommendations for wiring path and signal amplification if required

F. Provide samples and mockups for approval.
1. Provide Shop Drawings for approval of the mock ups.
2. Coordinate with finishes and mounting conditions.
3. Provide full size mockups of a portion of each LED system with actual wire lengths.
4. Alternate components shall be on hand during the mock up demonstration at the discretion of the LCSI.
5. Demonstrate LED system performance matching the design criteria specified in the Contract Documents.
6. Coordinate finishes and mounting conditions with the General Contractor and Design Team.
7. Document approved mockups and coordinate installation with the Electrical Contractor.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS SYSTEMS INTEGRATOR

A. Companies not listed herein seeking to bid on this work shall submit information as noted in Part 1.5 Lighting & Control System Integrator (LCSI) Requirements.

B. LCSI Contractors

4 Wall Lighting
Contact: Bill Groener
35 State St.
Moonachie, NJ 07074
(201) 329-9878

Barbizon Lighting
Contact: John Gebbie
456 West 55th Street
New York, NY 10019
(212) 586-1620

Supertech, Inc.
Contact: Steve Hamelin
22 North Plains Industrial Rd.
Suite #4
Wallingford, CT
(203) 294-9400

Vincent Lighting Systems
Contact: Paul Vincent
6161 Cochran Rd Suite D
Solon, OH 44139
(216) 475-7600

PART 3 - EXECUTION

3.1 LCSI SERVICES

A. Review the Contract Documents for performance criteria of the LED lighting systems.

B. Provide integration of LED luminaires and controls to comply with the Contract Documents.

C. Provide onsite coordination with the fixture manufacturer's field technicians.
   1. Where conflicts may arise between the System Integrator and the fixture manufacturer, the Electrical Contractor shall be responsible to deliver a working system matching the performance specifications as described in the contact documents.

D. Provide RDM compatible tools and software for remote configuration of the LED power supplies.

E. Project Management
   1. The LCSI shall designate a Project Manager.
   2. The LCSI's Project Manager shall be the main contact between the Systems Integrator, Manufacturers, Design Team and Contractors from contract award until final sign off. The LCSI's Project Manager shall be the same person throughout the entire course of the project.
   3. The LCSI's Project Manager shall attend a Kick-Off Meeting at the project site office or a place to be designated. The objectives of the Kick-Off Meeting are:
      a. Introduce the Project Team Members
      b. Review the Project Schedule
      c. Review the Scope of Work and any additional materials and documents not in the Scope of Work
      d. Layout the intent of the Project

e. Further define required mockups and work them into the schedule

F. Provide lighting system mock-ups as follows:
1. The Electrical Contractor shall provide fixture samples with drivers and dimming modules for mock-ups demonstrating the performance of the LED luminaries and controls.
2. Fixtures are not released for purchase until the fixtures, accessories and performance have been reviewed and approved in a demonstration. Fixtures listed in the submittals referenced herein may be rejected based on non-conformance to design criteria listed in the Contract Documents.
3. Mock up session shall take place during the course of one business day. The meeting shall take place within thirty (30) miles of the job site.
4. The mock up facility shall have no daylight penetrating the space and its lighting systems shall be shut off at random times during the demonstration. Design Team will require that the facility's lighting system be turned off throughout the review.
5. The demonstration shall be coordinated by LCSI. The Electrical Contractor shall notify the Owner's Representative and the Design team two (2) weeks prior to the demonstration day. LCSI's Project Manager shall attend the mock up.
6. LCSI shall review the information herein and make recommendations for execution of the mock up.
7. Power supplies and dimmers shall be on hand to provide substitute components which are found to be non-conforming.
8. Each fixture and system shall be clearly labeled with the contract document fixture code.
9. If the demonstration is incomplete, the contractor shall cover the expenses for the Design Team to return to the site for additional reviews.
10. The goal of the mock up is to verify the submitted fixtures match the specified performance criteria; therefore, it is essential all parts of the mock up are the actual models provided on the project. Fixtures and power supplies shall be held by the Owner's Representative as control samples for comparison to the installed products. Mock up components can be utilized in other demonstrations. Mock ups shall be returned to the contractor upon receiving the Certificate of Occupancy.

G. Coordination
1. Provide field coordination of the LED system installation
a. Review the drawings and site throughout the construction process. Notify the Electrical Contractor and General Contractor for any conditions which may be detrimental to the installation and performance of the LED systems
b. Review the LED system installation
c. Provide guidance and offer recommendations to the Electrical Contractor
d. Notify the General Contractor of any installation conditions which may be detrimental performance of the LED systems
e. Provide proper notification to factory authorized start up personnel as required for startup, testing and training service

f. Coordinate LED system start up with the Electrical Contractor and Lighting Control System Manufacturer
g. Set control addresses to the approved settings based on the mockups and control addressing schedules
h. Coordinate addressing with Lighting Control System Manufacturer for power supply power relay configurations
i. Run tests and tune the LED systems to match the performance requirements as stated in the Contract Documents

2. Notify the General Contractor when the systems are ready for review
   a. Demonstrate the performance of the LED lighting systems for approval by the Design Team and Owner's representative
   b. Coordinate with the electrical contractor and manufactures to correct deficiencies
   c. Coordinate, adjust, and set light levels for scene control with lighting designer and the Owner's representatives
   d. Coordinate with Owner to receive final control sequences and scene requirements. Program panels and recorders to Owner's final requirements
3. Provide Owner's manual including, but not limited to, the following:
   a. As-built drawings
   b. Two (2) sets of full sized Record Drawings to the owner for final acceptance. These drawings shall be fully revised and reflect the actual finished installation. The drawing set shall be 100 percent complete and shall include all schematics, details and Bill of Materials for future maintenance and repair of all systems supplied by the LCSI.
      i. Each drawing shall be dated and stamped as a Record Drawing.
      ii. Prints shall be full sized, stapled into sets. They shall be fully legible.
      iii. Any future revisions or modifications during the warranty period shall require that the Owner's Record Drawings be updated
4. The LCSI shall provide two sets of Instructions and Maintenance manuals to the Owner. The manuals shall consist of, but not be limited to:
   a. System Description
   b. User Operating Instructions
   c. User Maintenance Instructions
   d. Catalogue cut sheets from all equipment purchased
   e. Spare parts lists
   f. 11 inch by 17 inch reduced drawings of all system assemble drawings needed to perform system maintenance.
   g. Manuals shall be bound by the LCSI in loose-leaf binders and labeled with tabbed dividers for easy reference.

5. Training
   a. Provide two (2), four-hour sessions of training for the Owner's Representative.

END OF SECTION

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

A. This section includes company switches and pin and sleeve mechanical interlock switches.

B. CT DAS Warranty
   1. Refer to section 01 78 30 for specific information on warranty information

C. Section Includes:
   1. Work in the following spaces:
      a. Proscenium Theatre
   2. Systems:
      a. 200 Amp company switch

D. Related Sections:
   1. Division 11: Equipment:
      a. Section 11 61 33: Theatrical Rigging
   2. Division 26: Electrical
      a. Section 26 61 11: Theatrical Lighting Controls

1.3 REFERENCES

A. Reference Standards:
   1. National Fire Protection Association (NFPA) Publication: National Electrical Code, NFPA70
   2. Underwriters Laboratories Standards:
      a. UL498, Electrical Attachment Plugs and Receptacles
      b. UL508, Electrical Industrial Control Equipment
      c. UL891, Dead-front Electrical Switchboards
   3. American National Standards Institute
   4. International Building Code

1.4 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. DMX: Digital Multiplexing

C. NEC: National Electric Code

D. UL: Underwriters Laboratories, Inc.

1.5 SUBMITTALS

A. Provide submittals in accordance with General and Special Conditions. Submit submittals in a timely manner, allowing sufficient time for adequate review and possible resubmittal without jeopardizing the project schedule.

B. Shop Drawings:
   1. Submit shop drawings within ninety (90) days of award of contract, unless otherwise indicated in Division 1.
   2. Fabrication, Installation, and Erection shall not commence until shop drawings have been approved by the Architect and the Theatre Consultant.
   3. All sheets in the submittal shall be of the same size.
   4. Submittal shall include a title sheet listing all sheets in the submittal.
   5. Submittal shall show UL listing, compliance with NEC and local codes.

C. Commissioning Documentation:
   1. Certificates from the manufacturer's field engineer stating the installed system is operating properly and complies with manufacturer's recommendations

D. Record Drawings and Maintenance Manuals:
   1. Operations and Maintenance Manuals shall include:
      a. Contact information for manufacturers
      b. Safety and Operational Instructions
      c. Spare parts list and source information
      d. Wiring diagrams
      e. Certificates of compliance with applicable codes

1.6 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer: A firm who has been continuously engaged in the production of electrical equipment for at least fifteen (15) years.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver equipment and controls securely wrapped in factory fabricated wooden or fiberboard containers.

B. Handle equipment carefully to prevent breakage, denting and scoring finish. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Acceptance at Site: Contractor shall accept and inventory all equipment upon delivery and provide copies of the inventory to the architect.

D. Storage and Protection: Store equipment in a secure, environmentally controlled location. Place no equipment until that location is substantially completed, free from construction dust, and "broom clean." Store in original cartons and protect from dirt, physical damage, weather, and construction traffic.

1.8 PROJECT CONDITIONS

A. Field Measurements: Contractor is to verify all dimensions as they relate to requirements of the specification and manufacturer's requirements and is to notify the Owner's Representative of any variations, which would affect the installation and safe operation.

1.9 WARRANTY

A. Special Warranty:
   1. Provide warranty for systems and equipment to be free of defective components, faulty workmanship, and improper adjustment for a period of three (3) years from the date of substantial completion or acceptance by the Owner, whichever is later. Paint and exterior finishes are excluded. Replace items showing evidence of defective materials or workmanship (including installation workmanship) within thirty (30) days after notification. Make replacements without cost to the Owner.
   2. Rectify conditions that might present a hazard to human life, well-being, or property within forty-eight (48) hours of notification.

B. Designate warranties on manufactured equipment to the Owner to commence on the date of system acceptance.

1.10 COMMISSIONING

A. Provide demonstration and testing of systems described in this section. Training shall be made part of the system demonstration.

PART 2 - PRODUCTS

2.1 COMPANY SWITCHES

A. Manufacturers
   1. Lex Products, 15 Progress St., Shelton, CT 06484 (800) 643-4460
   2. SSRC, 170 Fortis Dr., Duncan, SC 29334 (864) 848-9770
   3. Union Connector, 40 Dale St., West Babylon, NY 11704 (631) 753-9550
   4. Electronic Theatre Controls, Middleton, WI (608) 831-4116

B. General:
   1. The company switch shall meet or exceed all applicable NEC standards and shall be UL listed. Labels denoting UL listing shall be riveted to the unit.
   2. Company switch enclosures shall not exceed the following dimensions:
      a. 200Amp – 38 inches high by 22 inches wide by 10 inches deep

3. Provide theatre style company switch with cam-lok connectors and connection chamber for bare wire tie-in.
4. Provide the company switches in the following configurations.
   a. 200Amp 5-wire plus ground

C. Construction
1. The company switch enclosure shall be fabricated of 14-gauge steel.
2. Enclosure shall have four welded mounting tabs.
3. The main breaker shall be recessed beneath the face of the front panel to prevent accidental operation.
   a. Breaker shall be equipped with a padlock attachment to lock the breaker in the off position.
4. The company switch shall have a wiring chamber which contains both direct wire lugs and single pole cam connectors.
   a. Both cam and lug cables shall drape downward when connected.
   b. Cam and lug connections shall enter and exit the wiring chamber from access holes in the bottom of the enclosure.
5. The enclosure shall contain a hinged door to conceal the output bus bars.
   a. This door shall be lockable and shall prevent access to the connections when mated.
   b. The access door shall engage the shunt trip mechanism of the main circuit breaker whenever it is not fully closed, ensuring connection cannot be made under load.
6. A strain relief bar shall be provided inside the connection chamber for securing load cables.
7. The sides and top of the enclosure shall be free of knockouts. All conduit entry shall be field punched.
8. Provide a warning label as required by code. This label shall specify the proper sequence for the connection and removal of cable connections.
9. The enclosure shall have a two-part polyurethane or baked enamel finish.
   a. Company switch finish shall be black.
10. Provide lamacoid plate on the face of the unit listing the capacity of the switch and intended use as listed above.

D. Electrical
1. Service inputs to the Company Switch shall be 120/208v, 3 phase.
2. Provide one (1) 100 percent rated 3-pole main breaker appropriately sized to specified amperages.
   a. Breaker shall have a 65K AIC rating
3. The main breaker shall contain a shunt-trip mechanism that will trip the breaker when the micro-switch monitoring the access door to the connection chamber is opened.
4. Internal and output lugs shall accept 500mcm cable.
5. All connections from the main breaker to the output panel shall be by copper bus.
6. Provide isolated ground connection for company switches so designated.
7. Provide white LED worklight in the wiring chamber.
   a. Work light shall turn on when door is opened.

8. The company switch shall contain LEDs to indicate voltage presence on each phase leg, and a green LED lamp to indicate ground integrity.
9. Provide digital ammeter indicating amperage on each leg.
10. Receptacles shall be 16 series cam-lok style panel mount connectors
11. The ground receptacle shall be isolated from the frame. A warning label shall be provided to indicate isolated ground if so designated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where company switches and interlocks are to be installed and verify that conditions are satisfactory for installation and comply with manufacturer’s requirements and those specified in this section.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install devices in accordance with manufacturer's instructions and with recognized industry practice to ensure that equipment complies with applicable requirements of NEC and UL standards and with the applicable portions of NECA's "Standard of Installation."

3.3 CLEANING

A. Remove paint spatters and other spots, dirt, and debris.

B. Repair scratches and mars of finish to match original finish.

C. Clean devices and equipment internally and externally using methods and materials as recommended by manufacturers.

3.4 DEMONSTRATION AND INSTRUCTION

A. The manufacturer of the company switches shall provide a minimum of two (2) hours of training in the operation of the switches specified herein. Training time to be arranged with the staff of the facility and shall take place over the first two (2) months after building acceptance.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES

A. Metal conduits and fittings.

B. Nonmetallic conduits and fittings.

C. Optical-fiber-cable pathways and fittings.

D. Metal wireways and auxiliary gutters.

E. Nonmetallic wireways and auxiliary gutters.

F. Surface pathways.

G. Boxes, enclosures, and cabinets.

H. Handholes and boxes for exterior underground cabling.

1.3 RELATED REQUIREMENTS

A. Section 26 05 33 - Raceways and Boxes for Electrical Systems: Conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.

B. Section 28 05 28 - Pathways for Security Systems: Conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

C. Connecticut State College & Universities “Telecommunication Infrastructure Standards”; Version 4.0, revision date: October 24, 2016.

1.4 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

1.5 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

C. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.6 INFORMATIONAL SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

C. Qualification Data: For professional engineer.

D. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Alpha Wire Company.
4. Anamet Electrical, Inc.
5. Electri-Flex Company.
6. O-Z/Gedney; a brand of EGS Electrical Group.
7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.
8. Republic Conduit.
9. Robroy Industries.
10. Southwire Company.
11. Thomas & Betts Corporation.
12. Western Tube and Conduit Corporation.
13. Wheatland Tube Company; a division of John Maneely Company.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. EMT: Comply with ANSI C80.3 and UL 797.

E. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel.
b. Type: Setscrew.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.

F. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Anamet Electrical, Inc.
4. Arnco Corporation.
5. CANTEX Inc.
6. CertainTeed Corp.
7. Condux International, Inc.
8. Electri-Flex Company.
9. Kraloy.
10. Lamson & Sessions; Carlon Electrical Products.
11. Niedax-Kleinhuis USA, Inc.
12. RACO; a Hubbell company.
13. Thomas & Betts Corporation.

B. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. RNC: Type EPC-40-PVC complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Rigid HDPE: Comply with UL 651A.

E. Continuous HDPE: Comply with UL 651B.

F. RTRC: Comply with UL 1684A and NEMA TC 14.

G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alpha Wire Company.
2. Arnco Corporation.
3. Endot Industries Inc.
4. IPEX.
5. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.
2. Hoffman; a Pentair company.
3. Mono-Systems, Inc.
4. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250 and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with TIA-569-B.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allied Moulded Products, Inc.
2. Hoffman; a Pentair company.
3. Lamson & Sessions; Carlon Electrical Products.
4. Niedax-Kleinhuis USA, Inc.

B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

C. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

E. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for

the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SURFACE PATHWAYS

A. General Requirements for Surface Pathways:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Mono-Systems, Inc.
b. Niedax-Kleinhuis USA, Inc.
c. Panduit Corp.
d. Wiremold / Legrand.

C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Hubbell Incorporated; Wiring Device-Kellems Division.
b. Lamson & Sessions; Carlon Electrical Products.
c. Mono-Systems, Inc.
d. Panduit Corp.
e. Wiremold / Legrand.

2.7 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.

3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. Hoffman; a Pentair company.
6. Hubbell Incorporated; Killark Division.
7. Lamson & Sessions; Carlon Electrical Products.
8. Milbank Manufacturing Co.
9. Molex; Woodhead Brand.
10. Mono-Systems, Inc.
11. O-Z/Gedney; a brand of EGS Electrical Group.
12. RACO; a Hubbell company.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-B.
2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Metal Floor Boxes:

1. Material: Cast metal
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Device Box Dimensions: as specified within the architectural drwaings.

J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

    a. Material: Plastic.
    b. Finished inside with radio-frequency-resistant paint.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Stage Area
    e. Stage Support Area
    f. Kitchen

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: GRC.
6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
7. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Plenum-type, optical-fiber-cable pathway.
8. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

B. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.

C. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

E. Install surface pathways only where indicated on Drawings.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg.

3.2 INSTALLATION

A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

C. Complete pathway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.

4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC before rising above floor.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT or GRC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

O. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

P. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.

Q. Surface Pathways:

1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch radius control at bend points.
3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

R. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.

2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

S. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.

T. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

X. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

Z. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

AA. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

BB. Set metal floor boxes level and flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.

B. Sleeve-seal systems.

C. Sleeve-seal fittings.

D. Grout.

E. Silicone sealants.

1.3 RELATED REQUIREMENTS

A. Section 07 84 13 - Penetration Firestopping: Penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

B. Connecticut State College & Universities “Telecommunication Infrastructure Standards”; Version 4.0, revision date: October 24, 2016.

1.4 ACTION SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Data: For each type of product.

C. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile

Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A53, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board

C. Sleeves for Rectangular Openings:

1. Material: Galvanized-steel sheet.
2. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.
2. Sealing Elements: EPDM or equivalent rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.

4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire- rated walls or floors.

B. Standard: ASTM C1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Sections 271100, 271300 and 271500

C. T-Series set of construction drawings.

D. Applicable portions of the construction documents for other disciplines.

E. All work shall comply with the latest edition of the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards. Where any conflict may exist with this Section or any of the related documents, the requirements of the CSCU standards shall take precedence.

1.2 SUMMARY

A. The intent of this section and the related documents is to obtain a professionally installed and complete structured cabling infrastructure to support network distribution. The contractor shall provide all labor, materials, tools, equipment, supervision, management, and anything else required to deliver a complete working system as defined in the relative construction documents. This shall include but not be limited to horizontal copper cabling, fiber optic and copper backbone cabling, all cable termination hardware, equipment room build-out, cables trays, J-hooks, sleeving, firestopping, system labeling and system certification.

B. Contractor shall coordinate work with drawings and specifications governing other disciplines. Provide work modifications, relocations or adjustments necessary to complete the work or to avoid interference with other trades. Document substantial variations in final record drawings.

C. Contractor shall field verify all measurements and conditions prior to installation.

D. Where architectural features impact location of work, refer to architectural drawings for details.

E. All work shall be performed in a neat and workmanlike manner as defined in ANSI/NECA 1 “Standard Practices for Good Workmanship in Electrical Contracting”. It is the responsibility of the Contractor to ensure that all state and local building codes are met. Any costs for changes to materials in order to meet code requirements shall be borne by the Contractor.

1.3 CONFIDENTIALITY

A. Contractor shall respect the confidentiality of the Owner, their staff, and other individuals associated with the project. No information relating to the project or staff shall be communicated to others outside of the project unless it bears on life safety for individuals or violations of applicable laws. Breech of this provision may be grounds for dismissal.

1.4 CERTIFICATES AND INSPECTIONS

A. At no additional cost to the Owner, the Contractor shall obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to the Owner unless otherwise directed. Provide all notices, file all plans and pay all fees as necessary to satisfy this requirement.

B. At the time of bid, bidders shall furnish proof of current eligibility to provide installation under the manufacturer's extended warranty program being proposed.

C. Equipment finishes:

1. Provide equipment with factory applied prime finish unless otherwise specified.
2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish or replace equipment to the satisfaction of the Architect.

1.5 CONFLICTS

A. Where an apparent or real conflict between specifications and drawings occurs, the document that requires the greater quantity or better quality shall govern, unless otherwise stipulated via RFI process.

1.6 REQUIREMENTS OF REGULATION AGENCIES

A. Rules and Regulations of Federal, State and Local authorities and utility companies that are in force at the time of execution of contract shall be incorporated in to this specification.

1.7 PRODUCTS INSTALLED BUT NOT SUPPLIED UNDER THIS SECTION

A. Outlet boxes, conduits, cable trays, sleeves, pull boxes, and necessary hardware needed for communications cabling pathways at outlet locations and along cable route, except for J-hooks and any supplementary support or penetrations required.

B. 3/4" plywood backboards in telecommunications equipment rooms.

C. Owner provided equipment

D. Rack power and convenience power in telecommunications equipment rooms and device power at data outlet locations.

E. Telecommunications grounding busbars (TGBs) and boding backbone infrastructure.

1.8 REFERENCES

A. All work shall comply with applicable sections of most recent editions of the following:

1. ANSI/TIA 568 – Commercial Building Telecommunications Cabling Standard
2. ANSI/TIA 569 – Commercial Building Standards for Telecommunications Pathways and Spaces
3. ANSI/TIA 598 – Optical Fiber Cable Color Coding
4. ANSI/TIA 606 – The Administration Standard for the Telecommunications Infrastructure of Commercial Building

5. ANSI/J-STD 607 – Commercial Building Grounding and Bonding Requirements for Telecommunications
6. ANSI/TIA 862 – Building Automation Systems Cabling Standard for Commercial Buildings
7. ANSI/TIA 942-A – Telecommunications Infrastructure Standard for Data Centers
8. ANSI/TIA/EIA 604-10-A – FOCIS 10 Fiber Optic Connector Inter-Matability Standard Simplex and Duplex Connectors with the Commercial Designation LC
9. ASTM D 4566-05 – Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable
10. BICSI Telecommunications Distribution Methods Manual (TDMM)
11. BICSI Information Technology Systems Installation Methods Manual (ITSIMM)
12. BICSI Outside Plant Design Reference Manual
13. Federal Communications Commission Part 15 and Part 68
14. ICEA S-83-596-2001 – Fiber Optic Premises Distribution Cable
15. ISO/IEC 11801 – Generic Cabling for Customer Premise
16. IEEE 802.3 Standard for Information Technology – Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
17. IEEE 802.3ae – 10 Gigabit Ethernet
18. IEC 61156-1 – Multicore and Symmetrical Pair/Quad Cables for Digital Communications
19. NECA/BICSI-568 – Standard for Installing Commercial Building Telecommunications Cabling
20. NESC 2012 – National Electrical Safety Code
21. NFPA 262 – Flame Travel and Smoke of Wires and Cables
22. NFPA 70 – National Electrical Code
23. NFPA 72 – National Fire Alarm and Signaling Code
24. NFPA 75 – Standard for Protection of Information Technology Equipment
25. NFPA 77 – Recommended Practice on Static Electricity
26. TIA TSB-162 – Telecommunications Cabling Guidelines for Wireless Access Points
27. TIA/EIA 455 Series – Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating devices, and other fiber optic components.
28. TIA 862 – Building Automation Systems Cabling Standard
29. UL 444 – Standard for Safety of Communications Cable
30. UL 1666 – Standard for Safety of Flame Propagation Height
31. UL-1863 – Communications Circuit Accessories
32. UL-94V – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.9 DEFINITIONS

A. The following acronyms and terms may appear in the project documents:
   1. ADA – Americans with Disabilities Act.
   2. AFF – Above Finished Floor
   3. AHJ – Authority Having Jurisdiction

4. ANSI – American National Standards Institute
5. ASTM – American Society for Testing and Material
6. AWG – American Wire Gauge
7. Baseband – single un-multiplexed signaling
8. BICSI – Building Industry Consulting Services International
9. BISCUIT – Small surface mount jack
10. CAD – Computer Assisted Design
11. CATV – Community Antenna Television
12. CCTV – Closed-circuit Television
13. CFCI – Contractor Furnished Contractor Installed
14. COTS – Commercially available Off The Shelf
15. EF – entrance facility
16. ER – equipment room
17. EIA – Electronics Industry Association
18. FDC – Fiber Distribution Center
19. ft – feet
20. GbE – Gigabit Ethernet
21. Hz – frequency in Hertz
22. ICEA – Insulated Cable Engineers Association
23. IDC – Insulation Displacement Connector
24. IEC – International Electro Technical Commission
25. IEEE – Institute of Electrical and Electronic Engineers
26. ID – inside diameter
27. IDC – insulation displacement contact
28. Install – Shall mean furnish and install
29. ISO – International Organization for Standardization
30. J-STD – Joint Standard
31. LAN – local area network
32. lbs – pounds
33. Level III or Level IV – tester accuracy established by UL
34. Mbps – Megabits per second
35. MC – main cross-connect (MDF)
36. MHz - Megahertz
37. µm – Micrometer/Micron: Unit of measure for which is one millionth of a meter
38. Multimode – optical fiber designed to carry multiple carrier signals distinguished by frequency or phase at the same time
39. NEC – National Electrical Code
40. NECA – National Electrical Contractors Association
41. NEMA – National Electrical Manufacturers Association
42. NESC – National Electrical Safety Code

43. NETA – National Electrical Testing Association
44. NFPA – National Fire Protection Agency
45. NIST – National Institute of Standards and Technology
46. OD – outside diameter
47. OFOI – Owner Furnished Owner Installed
48. OFCI – Owner Furnished Contractor Installed
49. OLTS – optical loss test set
50. Ohm – measure of electrical resistance or impedance
51. OSHA – Occupational Safety and Health Administration
52. OSP – outside plant
53. OTDR – optical time domain reflectometer
54. PVC – polyvinyl chloride
55. RCDD – Registered Communication Distribution Designer
56. RL – Return Loss is the ratio, expressed in decibels, of the power of the outgoing signal to the power of the signal reflected back
57. RU – rack unit (1.75")
58. Single-mode – an optical fiber designed to allow only one mode of light to propagate
59. sq ft – square feet
60. TIA – Telecommunications Industry Association
61. TDR – time domain reflectometer
62. TE – telecommunications enclosure
63. TR, Telecomm Rm - Telecommunications room
64. TSB – Telecommunications System Bulletin
65. UL – Underwriters Laboratory
66. UTP – Unshielded Twisted Pair
67. WAN – wide area network
68. WAP – Wireless Access Point
69. WLAN – wireless local area network

1.10 SUBMITTALS

A. Pre-Bid Submittals

1. With their bid, the Bidder shall submit a statement of qualifications to proficiently perform the scope of work as specified. At minimum, this submittal shall include the following:
   a. A list of projects of comparable scope and magnitude to the work being bid upon that have been completed by the bidder within the last five (5) years. The listing shall indicate the project name and address, the year of completion, and the name and contact information for a representative of the Owner that was related to the project.
   b. The resume of the project manager that would be dedicated to the project for its duration. Substitution of the project manager shall not be permitted without resubmission and approval by the Owner's representative.
   c. A statement of bidder's capabilities for producing AutoCAD drawings for submittal of Shop Drawings and As-Built Drawings.

d. Official certification by the hardware manufacturer(s) indicating that the bidder is authorized to provide a minimum of a 20-year system warranty as specified herein.

B. Bid Submittals:

1. Bidders shall examine all drawings and specifications to avoid omissions and duplications and ensure completeness of their offering. No allowance shall be made for any failure to thoroughly review and understand the bid documents. Any apparent discrepancies or omissions within the bid documents shall be referred to the Owner's representative for clarification prior to bidding. Where discrepancies occur and clarifications have not been sought prior to bidding, the contractor shall agree to abide by the decision of the Owner's representative.
2. Bid proposals shall account for all work and equipment specified, as well as any other elements required to produce a complete working system.
3. Requests for project scope clarification shall be submitted in writing no later than three (3) days prior to the bid date, or as otherwise specified in the bid documents.
4. No portion of the scope of work being bid upon shall be subcontracted or otherwise assigned to a third party unless identified in detail with the bid. All qualifying conditions applied to the bidder shall also apply to the sub-contractor. Bidders are required to submit third-party qualifications with their bids as specified herein.
5. Bid submittals shall include the following:
   a. The total lump-sum price for the full scope of work.
   b. An itemized list of all equipment and materials to be used in assembling the system.
   c. Unit add/deduct pricing for all major items on the equipment list.
   d. Lot pricing for miscellaneous items not included in the submitted equipment list.
   e. A breakdown of the number of staff hours allotted for:
      1) On-site coordination meetings and supervision
      2) In-shop engineering
      3) On-site assembly and installation
      4) On-site verification and testing
6. Proposed substitutions:
   a. Any item proposed as a substitute for an item specified shall be submitted for and approved in writing by the Owner's representative prior to bid submission.
   b. In submitting for a substitution, the bidder shall demonstrate that the proposed substitution meets or exceeds the essential characteristics of the item specified.

C. Shop Drawing Submittals:

1. Shop drawings shall be submitted and approved prior to the start of work. Any work performed without an approved shop drawing may be subject to removal and replacement at the Contractor's expense if, at the sole discretion of the Owner's representative, such work does not comply with the intent of the construction documents.
2. Submitted shop drawings shall be neatly organized and presented and, at minimum, shall include the following:
   a. Table of contents
   b. Itemized list, with quantities, of all equipment and materials to be installed
   c. Manufacturers' data sheets for each listed item. Where multiple product variations are indicated in the submitted manufacturers' literature, the Contractor shall clearly indicate the specific item being submitted.
   d. A complete list of all cable runs, identifying cable numbers, cable types, termination locations of both cable ends, and estimated cable lengths
   e. Scaled and labeled plan view drawings showing equipment layouts and relevant clearance measurements. All components to be installed shall be represented.

f. Scaled and labeled rack and wall elevations showing equipment mounting with relevant measurements. All components to be installed shall be represented.
g. Labeling plan for all racks, cabinets, enclosures, patch panels, blocks and data outlets. Labeling plan shall comply with CSCU Telecommunications Infrastructure Standards.
h. Test plan with sample test data format.

3. Submittals that are incomplete or not properly reviewed by the Contractor prior to submitting may be returned to the Contractor without review.

D. Samples

1. Submit samples of any approved substitute materials to the Owner's representative as required to demonstrate equivalency to items specified.
2. Submit samples of custom work, finishes or other materials as required by the Owner's representative, Architect or Systems Designer to verify appearance and quality.
3. Costs for obtaining and shipping samples shall be borne solely by the Contractor.

E. Documentation for Final Acceptance

1. Provide three (3) copies of an operation and maintenance manual, including the following:
   a. Table of contents and tabs for each piece of equipment or system
   b. Copies of all warranty certificates, specifying the Owner as being entitled to all rights guaranteed by the warranty
   c. Copies of approved product submittals
   d. Copies of approved shop drawings
   e. Copies of complete system certification report
   f. Copies of as-built documents as specified herein
2. As-Built Documents:
   a. Provide as-built drawings in accordance with Division 1.
   b. Provide scaled drawings in project standard format (e.g., 30" x 42"), using the issued construction drawings as a basis.
   c. Indicate final data outlet locations and types, data outlet labeling, cable routing, pathway labeling where applicable, and labeling of racks, cabinets and enclosures.
   d. Submit in electronic form for review and in large-format printed form for inclusion in operation and maintenance manuals.

1.11 JOB CONDITIONS

A. Adequately staff the project whenever on-site to perform work. Except where prevented by illness, attrition or other circumstances beyond the Contractor's control, the Contractor shall maintain consistency of key personnel assigned to the project.

B. Cooperate with all appropriate parties to maintain progress, coordinate with the overall construction schedule, and obtain satisfactory outcomes.

C. Cooperate in resolving conflicts with the work of other contractors. Perform moderate moves or changes as necessary to accommodate other equipment and complete a satisfactory result without claim for additional compensation.

D. Promptly report any design or installation irregularities to the Owner's representative so that appropriate resolution may be determined.

E. Coordinate with other trades to ensure the timing and completeness of elements by others that are required to complete the Contractor's scope of work.

F. Repair any damage caused by the Contractor to the satisfaction of the Owner's Project Manager and at the Contractor's expense.

G. Maintain a clean work area and remove construction waste on a daily basis. Dispose of waste off-site or as otherwise directed by the Owner's Project Manager.

1.12 QUALIFICATIONS

A. Quality Assurance

1. Install all components as directed by the product manufacturers.
2. Arrange for and pay for any required permits, licenses and inspections, and observe any stipulations cited therein. Comply with all applicable codes, statutes and regulations.
3. Provide only listed products, as applicable. All signal-carrying components shall bear an appropriate official mark indicating performance level as verified by ETL or UL.
4. All products shall be in new and unused condition in manufacturers' original packaging.

B. Manufacturer Qualifications

1. Component manufacturers shall be specialized in the manufacture of telecommunications products with a minimum of 15 years of experience producing the types of components used.

C. Bidder Qualifications

1. Employ a Registered Communications Distribution Designer (RCDD) to professionally review and seal all submittals, shop drawings, installation methods, commissioning, and testing and certification of all elements of the scope of work.
2. Employ experienced technicians and installers who will consistently be assigned to the work until it is complete.
3. Bidders shall be licensed or otherwise certified to install telecommunications systems in the state where work will be performed, as required by state or local jurisdiction.
4. Bidders shall have a minimum of 5 years of experience installing structured cabling systems for telecommunications in projects of similar scope and magnitude.
5. The Contractor shall not utilize subcontractors or any third parties for any portion of the work unless written permission is obtained from the Owner's representative prior involvement.

D. Installer Qualifications

1. The Installer shall be knowledgeable of all applicable industry codes and standards including, but not limited to, those produced by NEC, TIA and BICSI, and shall comply with all applicable regulations of local, state, and federal governments and any authority having jurisdiction. Any failure to pass inspections by any regulatory body shall be corrected wholly at the expense of the Installer and without cost to the Owner
2. The Installer shall maintain a minimum of one on-site supervisor and one technician, certified by the manufacturer to install the manufacturer's products under their extended warranty program. Proof of manufacturer certification shall be submitted prior to performing any associated work.
3. The installer shall have been trained by the manufacturer and approved by the manufacturer to install a system to be covered by the manufacturer's extended warranty.

E. Testing Agency Qualifications

1. Product listing agencies shall be independent and recognized by industry for definitive, independent verification of the performance of copper and fiber optic cabling components.

1.13 PRECONSTRUCTION MEETING

A. The Contractor shall organize and conduct a preconstruction meeting if the General Contractor or Owner's Project Manager do not do so.
   1. Invitees shall include representatives of the Owner, General Contractor, design consultant, and other disciplines deemed appropriate.
   2. The meeting shall be to review the Contractor's scope of work and the project schedule and to clarify any issues relevant to completing the project in an acceptable manner.

1.14 DELIVERY, STORAGE, AND PROTECTION

A. Cooperate as prescribed by the construction site manager for all materials deliveries to the project site, on-site storage of materials, and distribution of materials to work areas within the project area.

B. The Contractor shall be responsible for the handling and storage of materials as prescribed by the respective product manufacturers.

C. The Contractor shall be responsible for all materials, tools, equipment, vehicles and other possessions left on the job site.

1.15 PROJECT CONDITIONS

A. Environmental Requirements
   1. Ensure that any pollutants produced in the performance of the work are disposed of according to national, state or local regulations, following the most stringent guidelines.
   2. Recycle any used or un-used components during the course of the project and otherwise cooperate as applicable with project LEED objectives.

B. Field Measurements
   1. Inspect conditions and measure all spaces for equipment installation. Alert appropriate parties to any potential issues and cooperate with determinations made.

1.16 SEQUENCING

A. Coordinate with the construction manager on the sequencing and timing of the efforts of the various trades and construction teams for the duration of the project.

1.17 SCHEDULING

A. Provide a detailed construction schedule with fixed dates for completion of cable rough-in, termination and testing. Scheduling shall be coordinated with the overall project schedule.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Wherever any equipment is specified by manufacturer and model number, it is for purposes of establishing a standard of quality, performance, construction and function.

B. The contractor shall utilize cabling system components that are of commercial grade, in new and unused condition, and of the latest version offered by the manufacturer.

2.2 SOURCE QUALITY CONTROL

A. Materials shall be procured from sources authorized by the manufacturers to sell their products.

2.3 PROJECT DETAILS

A. Furnish all material and labor to finish all work and provide a complete working system as intended, even where specific details may not be represented in the project drawings.

PART 3 - EXECUTION

3.1 TELECOMMUNICATIONS SYSTEM REQUIREMENTS

A. Requirements of these specifications are related to complete and cohesive systems. Where conflicts exist with other specifications, these specifications shall take precedence, unless otherwise directed in writing by the Owner's representative.

3.2 INSTALLATION

A. Work performed shall conform to applicable laws, ordinances and regulations, and to the requirements of any utility companies involved.

B. As applicable, components shall meet the requirements of FCC Rules and Regulations Parts 15 and 68. For system installation work that is governed by the FCC, work shall be performed in accordance with FCC Rules and Regulations by parties license and registered with the FCC.

C. Any deviations from specifications must be submitted for in advance, in writing, presenting justification, and be approved by the system designer and the CSCU Telecommunications Department.

D. The Installer shall comply with all laws and regulations regarding safety, protection and insurance. All equipment installed shall be firmly secured in place with appropriate fasteners and supports as prescribed by the manufacturers and by applicable codes and standards. Cables in ceiling spaces shall be properly supported by building structure and shall not be supported by or in any way affixed to any component of a suspended ceiling system.

E. All cables shall be labeled at both ends in accordance with CSCU Telecommunications Infrastructure Standards. Where not in conflict with CSCU standards, labeling shall be provided per the latest edition of the TIA-606 standard.

F. All cabling shall be neatly laced, dressed, and adequately supported. Cable splices shall not be permitted except where specified otherwise.

G. Contractor shall take care to avoid damage to cable and equipment, both new and existing, and to protect the building areas adjacent to the work being performed. Penetrations through rated structures required for cable passage shall be sealed by the Contractor in accordance with applicable fire and building codes.

H. At the conclusion of the project, the Contractor shall remove all dust, dirt, wire clippings and other debris from all telecommunications racks and cabinets and from telecommunications equipment room floors.

I. All work performed shall be done professionally and shall conform to manufacturers' recommendations and industry best practices. The Owner's project manager, system designer, or CSCU Telecommunications Department may interrupt any work due to poor workmanship or other improper execution. Any deficiencies in the work shall be corrected at the Contractor's expense.

J. Observe installation practices specified in the most recent editions of applicable TIA Standards, BICSI Standards, NFPA-70 National Electric Code, and National Electrical Safety Code.

K. Adhere to installation practices specified by the respective product manufacturers.

L. Locate all components requiring adjustments, cleaning or other servicing so that service access is maintained. Position equipment racks to permit full front and rear access for system operation and service.

M. The equipment specified herein is designed to operate in environments of normal temperature, humidity and dust. Protect equipment where extreme environmental conditions can occur.

N. Review and coordinate cable trays, sleeves and other pathway components with the Electrical Contractor and the construction drawings to ensure proper placement and sizing.

O. Coordinate all special-purpose data outlet locations with equipment providers for which the data outlets are being provided or where cables and/or terminations will be housed in common enclosures or panels. Refer to drawings to determine locations of standard data outlet types.

P. Prior to any work in telecommunications equipment rooms, ensure that all plywood backboards are painted with flat white paint, or other color as specified, using two coats of fire retardant paint on all sides.

Q. Ensure that telecommunications equipment rooms are cooled to between 64 and 72 degrees Fahrenheit, with a relative humidity level of 30 to 55 percent, on a 24-hour basis. Install copper and fiber optic cable connectors and panels only in dust-free environments.

R. Conduit/Sleeve Installation

1. Review and coordinate conduit and sleeve installations with the Electrical Contractor to ensure proper placement and size.
2. Where installed above ceilings or in walls, ensure that conduits are routed parallel and/or perpendicular to the walls or ceilings and are properly supported.
3. Ensure that minimum conduit size used is 1 inch and that maximum conduit fill ratio, as required by code, will not be exceeded.

4. Ensure that no more than two 90-degree bends, or a combination of bends not exceeding 180 degrees, occurs in any segment of conduit between two permanently accessible pull points.
5. Ensure that all conduit/sleeve ends, including those inside of outlet boxes, pull boxes or junction boxes, are equipped with protective bushings prior to any cable placement.
6. Ensure that the radius of any conduit bend is not less than the following:
   a. Six times the conduit diameter for conduits up to 2-inch trade size
   b. Ten times the conduit diameter for conduits larger than 2-inch trade size
7. Condulets or similar devices shall not be permitted unless specifically identified in the construction documents.
8. Ensure that conduit distances between permanently accessible pull points do not exceed 100 ft.
9. Ensure that pull strings are included with all conduits.

S. Electrical Power

1. Review and coordinate all electrical power system installations, as well as installation of telecommunications grounding and bonding, with the Electrical Contractor to ensure proper installation and operation.

T. Raceways

1. Review and coordinate with Electrical Contractor regarding all raceways, including outlet boxes, stub-ups, conduits and sleeves, to ensure proper installation prior to use.
2. Ensure that all boxes and conduits are securely mounted to building structure and that all boxes are installed to be accessible for cable placement.
3. Ensure that all boxes and conduits are clear of debris prior to installing cabling, outlet assemblies and plates.
4. Ensure that all conduit ends, including those inside of boxes, are equipped with protective bushings prior to cable placement.

U. Grounding

1. All telecommunications grounding busbars (TGBs) and bonding conductors shall be installed by the electrical contractor.

V. Wiring Methods and Practices

1. Observe proper cabling methods and practices concerning, but not limited to, the following:
   a. Pulling tensions
   b. Quantities
   c. Types
   d. Lengths
   e. Routing
   f. Electrical Separation
   g. Labeling
2. Cable splicing shall not be permitted except where specifically indicated in the construction documents.
3. Do not pull wire or cable through any pull box where corresponding conduits are not aligned or where a change of direction occurs and do not bend conductors to less than the minimum cable bend radius. Use temporary guides, sheaves, and/or rollers to protect cables from excessive tension, abrasion, bending or damage during installation.

4. Provide cable pulling lubricants and tension limiters in accordance with the recommendations of the cable manufacturers and industry standards. Lubricants used shall not affect the electrical characteristics of the cable.
5. All cables shall be permanently identified with machine printed labels at each end as specified. All cable labeling shall be compiled in database or tabular form and provided to the Owner at the completion of the project.
6. At minimum, all patch panels shall be labeled with an alpha character in a top-to-bottom sequence.
7. At minimum, all data outlet port labeling shall include the identification letter of the patch panel and the panel port number on which that cable is terminated.
8. Provide ample service loops at each termination so that jacks and faceplates can be dismounted for service and inspection. Where possible, provide 12 inches at the work area and 10 feet in the telecommunications equipment room. Properly store and secure service loops as specified.
9. Firestopping of all penetrations through rated structures shall be performed per applicable codes and in accordance with approved UL firestopping systems. Utilize intumescent putty inside of raceways or other firestopping products that permit access to cabling and subsequent restoration of the firestopping system.

3.3 FIELD QUALITY CONTROL

A. Maintain availability of all ceiling and termination work for inspection by the AHJ, Owner, Project Manager, system designer or other parties as required.

B. All defective components and deficient workmanship shall be replaced at the Contractor's expense.

3.4 SCOPE ADJUSTMENTS

A. No additional work outside of the contracted scope of work shall be performed without the approval of the Owner or Owner's representative.

3.5 CLEANING

A. Clean all equipment cabinets, racks, patch panels and floors prior to turnover to the Owner.

3.6 PROTECTION

A. Ensure that all equipment is protected from dust, water and construction debris throughout the course of the project. Cover all connectors and terminations with plastic or other dust-proof covering during construction. Remove all protective measures prior to turnover to the Owner.

3.7 SCHEDULES

A. Coordinate all work with Owner's project manager and follow scheduling sequence and timing as established by Owner's project manager.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Sections 271000, 271300 and 271500

C. T-Series set of construction drawings.

D. Applicable portions of the construction documents for other disciplines.

E. All work shall comply with the latest edition of the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards. Where any conflict may exist with this Section or any of the related documents, the requirements of the CSCU standards shall take precedence.

1.2 SUMMARY

A. Section Includes:

1. Communications racks

2. Communications patch panels

3. Communications cable management

4. Communications grounding and bonding

1.3 LEED BUILDING GENERAL REQUIREMENTS

A. Refer to section 27 10 00.

1.4 REFERENCES

A. Refer to 27 10 00.

1.5 DEFINITIONS

A. Refer to 27 10 00

1.6 SYSTEM DESCRIPTION

A. The Contractor shall be responsible for the complete build-out of the telecommunications equipment room, including but not limited to plywood backboards, equipment racks, ladder

racks, rack-based vertical and horizontal cable management, patch panels and termination blocks, and grounding and bonding for telecommunications.

B. Two-post equipment racks shall be provided as indicated in the construction drawings. Racks shall be securely fastened to the floor.

C. 48-port, rack-mounted modular patch panels shall be provided for termination of horizontal copper cabling. Rack-mounted fiber optic enclosures with adapter panels shall be provided for termination of fiber optic cabling.

D. Wall-mounted termination blocks shall be provided for termination of copper backbone cabling, which shall be extended to 24-port rack-mounted patch panels.

E. Ladder rack shall be provided as indicated in the construction drawings to support cable routing within the equipment room. Ladder rack shall be equipped with radius-controlling devices, designed specifically for the purpose, at all cable-route transition points.

F. Rack-based vertical and horizontal cable management products shall be provided with the equipment racks to facilitate orderly routing of cables to termination points within the racks while limiting cable bend radius. The same devices shall be used to manage patch cord routing at the front of the equipment racks.

G. All equipment racks, ladder racks and other metallic components installed by the Contractor shall be bonded to the telecommunications grounding and bonding infrastructure.

1.7 SUBMITTALS

A. Refer to Section 27 10 00

B. Shop Drawings:

1. Prior to installation, furnish shop drawings showing equipment layouts in plan and elevation view, showing clearance measurements on scaled drawings.

2. Submit shop drawings in electronic form, in either AutoCAD (.dwg) or PDF format.

3. Shop drawings shall be approved by the system designer prior to installation. Any work performed without approved shop drawings may be subject to removal and replacement at the Contractor's expense.

C. Product Data:

1. Prior to installation, furnish manufacturers' product data for all components to be installed.

2. All product data submittals shall consist only of literature produced by the manufacturer with markings by the Contractor to indicate specific product selections.

3. Product data shall be submitted in electronic form, such as PDF versions of cut sheets.

4. Product data shall be approved by the system designer prior to installation. Any work performed without approved product data submittals may be subject to removal and replacement at the Contractor's expense.

PART 2 - PRODUCTS

2.1 EQUIPMENT RACKS

A. Equipment racks shall be two-post models of the 19"-wide standard, as defined by EIA-310-D, with the following characteristics:

1. 84" height – minimum of 45 rack mount units (RMU)

2. Minimum of 1,000-pound equipment weight capacity

3. #12-24 threaded holes for equipment mounting, spaced on 5/8"-5/8"-1/2" pattern per EIA-310-D

4. Black finish

2.2 VERTICAL CABLE MANAGERS

A. Vertical cable managers shall be double-sided with the following characteristics:

1. Full height of equipment rack

2. Width as indicated on construction drawings – minimum width shall be 6".

3. Provisions to aid in routing, managing and organizing cable to and from equipment and for limiting cable bend radius and providing cable strain relief.

4. Open cabling section on the rear to provide easy access and facilitate the routing of cable bundles and the feeding of cables into the back of patch panels.

5. Cable guides on front with radius-controlling fingers spaced at 1 RMU to enable fanning and managing of patch cords.

6. Door/cover on front only with retaining latches, able to be opened from both right and left sides and easily removable and replaceable to allow for open access when needed.

7. Black color

2.3 HORIZONTAL CABLE MANAGERS

A. Horizontal cable managers shall have the following characteristics:

1. Two rack mount units (2 RMU) in height or as otherwise specified in the construction documents.

2. Provisions to aid in routing, managing and organizing cable to and from equipment and for limiting cable bend radius and providing cable strain relief.

3. Full-width cover, able to be opened from both top and bottom and easily removable and replaceable to allow for open access when needed.

4. Cable retaining devices to hold cables in place while cover is opened or removed.

5. Black finish

2.4 PATCH PANELS

A. Reference Sections 271300 and 271500.

2.5 FIBER OPTIC ENCLOSURES

A. Reference Section 271300.

2.6 TERMINATION BLOCKS

A. Reference Section 271300.

2.7 LADDER RACK SYSTEM

A. The ladder rack system shall consist of rigid sections, and associated joining and mounting components, with the following characteristics:

1. Width as indicated in the construction drawings. Minimum width shall be 12”.

2. Minimum cross sectional stringer dimensions of 1-1/2”H x 3/8”W

3. Radius drop fittings available for mounting on cross members and stringers to limit cable bundle bend radius in route transition from horizontal ladder rack to vertical cable manager.

4. Means of adjusting spacing of cross members or adding components to vary cross member positioning so that alignment of radius drop fittings with vertical cable managers may be optimized.

5. Available accessories for forming tee junction splices, butt splices, wall-butt end mounting, longitudinal wall mounting, ceiling hanging, covering exposed stringer ends, radius corner brackets for easing horizontal cable route transitions, and components for bonding to TGB.

6. Rigid construction – basket-type cable tray products shall not be used inside of telecommunications equipment rooms. Rigid cable tray systems designed primarily for use in corridors and interstitial building spaces shall not be used inside of equipment rooms.

7. All system components shall be UL approved for use with communications cabling.

8. Black finish.

2.8 CONDUIT WATERFALLS

A. All openings of 4" conduits and sleeves that are greater than five feet above the height of an associated equipment room ladder rack or corridor cable tray shall be equipped with radius-controlling devices to limit the bend radius of cable bundles where they emerge from the conduits or sleeves.

2.9 GROUND BAR

A. A telecommunication grounding busbar (TGB) shall be provided in all telecommunications equipment rooms and shall have the following characteristics:

1. Minimum height of 2" and minimum thickness of 1/4". Length as determined by number of connections. Minimum length shall be 12".

2. Electrotin plated for reduced contact resistance.

3. Equipped with 2" insulating standoffs for wall mounting.

4. Compliant with the latest edition of the TIA-607 standard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plywood Backboards

1. Provide 3/4" plywood backboards continuously from 0'-6" AFF to 8'-6" AFF on all walls from corner to corner.

2. Provide plywood that is sanded on one major surface.

3. Mount plywood sheets in vertical orientation, with smooth side facing into room.

4. Secure plywood to wall structure with a minimum of five (5) equally spaced fasteners along each vertical edge and down the centerline of each sheet of plywood. Fasteners shall be of the appropriate type for each wall substrate.

5. Provide blocking or additional studs in framed walls as required to secure the fastening of the plywood.

6. Thoroughly cover plywood with two coats of fire retardant paint or as otherwise prescribed by local code. To enable field verification of the plywood type installed, do not paint over at least one legible grade stamp on each sheet of plywood.

B. Equipment Racks

1. Install equipment racks in accordance with manufacturer's instructions.

2. Securely fasten equipment racks to floor in each of the four corners of the base flange with minimum 3/8" hardware.

3. Install racks to be plumb and square, without racking or twisting, and to finish at matching height with adjacent racks.

4. Mount racks to ensure a minimum of 36" of clear space at front and rear of rack and on at least one end of rack row.

5. Bond all racks to TGB as follows:
   a. Utilize #6 copper ground wire with green insulation.
   b. For multiple racks, bond each rack individually to TGB. Do not loop from one rack to another.
   c. Remove rack finish to bare metal at bonding point. Apply anti-oxidation compound to bonding connection, following manufacturer's instructions.
   d. Use 2-hole lugs for all bonding connections to equipment racks and TGB.
   e. Comply with the latest edition of TIA-607.

C. Ladder Rack System

1. Provide a ladder rack system inside of the telecommunications equipment rooms as indicated in the construction drawings.

2. Install ladder rack system on a level plane at 8'-6" AFF.

3. Support ladder rack at maximum intervals of five feet, or at shorter intervals if prescribed by the manufacturer, using manufacturer-approved fittings and hardware designed for the purpose.

4. Where a ladder rack segment terminates into a wall at a perpendicular, support the end of the ladder rack with an appropriate wall angle support kit, as follows:
   a. Min. 2" x 2" angle iron of min. 3/16" thickness, in a single length extending min. 1" beyond the width extent of the ladder rack on each side.
   b. Fasten angle iron to plywood backboard in level, horizontal orientation with min. 3/8" hardware. Mount with flat side at top.
   c. Secure both stringers of ladder rack to flat side of angle iron with min. 5/16" J-bolts.

5. Where support is required along a ladder rack's span where running adjacent to a wall, provide a triangular support bracket to extend across the entire width of the ladder rack. Secure support bracket to wall with min. 3/8" hardware and secure both stringers to support bracket using min. 5/16" J-bolts.

6. Where support is required along a ladder rack's span where there is no wall or rack structure on which to anchor support, hang from overhead building structure with min. 3/8" threaded rod secured to each stringer with an appropriate threaded rod bracket. Secure threaded rods to building structure with appropriate hardware designed for the purpose and in a manner acceptable to the construction manager.

7. Ladder rack segments that intersect the tops of equipment racks may be supported from those equipment racks with min. 3/8" hardware and appropriate brackets for securing to both the equipment rack and the ladder rack stringers. Ladder racks shall stand off of any equipment rack by min. 6" to allow for radius controlled cable routing transitions.

8. Provide ladder rack radius drop fittings above all vertical cable managers, as follows:
   a. Align lower edges of radius drops with outside edges of vertical cable managers.
   b. When radius drops are mounted to ladder rack cross members, provide two radius drops per vertical cable manager, facing each other, to accommodate cables approaching from both directions.
   c. With cross member mounting, provide moveable ladder rack cross members or other means to optimize radius drop alignment with outer edge of cable manager.
   d. With cross member mounting, provide radius drop width to match width of ladder rack.
   e. With stringer mounting, provide radius drop width to match front to back extent of cable manager.
   f. Secure radius drops to ladder racks as prescribed by the manufacturer.

9. Secure all intersections of ladder rack segments using appropriate tee-junction hardware kits and butt-splice kits as prescribed by the manufacturer.

10. Cover all exposed ends of ladder rack stringers using appropriate end closing hardware kits or rubber end caps.

11. Remove any burrs from cut sections of ladder rack.

12. Bond ladder rack system to TGB as follows:
   a. Utilize #6 copper ground wire with green insulation.
   b. Either bond each segment of ladder rack individually to TGB or utilize trunk and tap method with #2 copper ground wire for trunk and #6 copper ground wire for each tap. For trunk and tap method, use non-reversible compression tap fittings designed for the purpose.
   c. Remove ladder rack finish to bare metal at bonding points. Apply anti-oxidation compound to bonding connection, following manufacturer's instructions.
   d. Use 2-hole lugs for all bonding connections to ladder rack and TGB.
   e. Comply with latest edition of TIA-607.

13. Comply with the manufacturer's recommendations for all methods and details of the installation of the ladder rack system.

D. Cable Management

1. Provide vertical cable managers as indicated on the construction drawings and per approved shop drawings. Install per manufacturer's instructions.

2. Provide horizontal cable managers as indicated on the construction drawings and per approved shop drawings. Install per manufacturer's instructions.

E. Rack-Mounted Copper Patch Panels and Fiber Optic Enclosures and Wall-Mounted Terminal Blocks

1. Provide as indicated on the construction drawings and per approved shop drawings. Install per manufacturer's instructions.

2. Provide cable support mechanisms at rear of copper patch panels to support cables being laced to termination points.

F. UL Listed Fire Rated Pathway

1. All penetrations through fire-rated structures shall be properly fire-stopped in accordance with the National Fire Protection Association (NFPA), NFPA-70 NEC Article 300, and the latest edition of TIA-569.

2. Each installation of firestopping material shall only be used in applications as specified by the firestop manufacturer. When placing additional cabling after firestopping had previously been completed, the firestop system shall be reevaluated and, if necessary, a new firestop system installed to restore the firewall integrity per the applicable UL-classified system. Only use of UL-classified firestop systems shall be acceptable.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Sections 271000, 271100 and 271500

C. T-Series set of construction drawings.

D. Applicable portions of the construction documents for other disciplines.

E. All work shall comply with the latest edition of the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards. Where any conflict may exist with this Section or any of the related documents, the requirements of the CSCU standards shall take precedence.

1.2 SECTION INCLUDES

A. Fiber optic and copper backbone cabling systems for interconnection of telecommunications equipment rooms.

1.3 SUMMARY

A. Fiber Optic Backbone

1. 24-fiber single mode, type OS2, type OFNP

2. 24-fiber multimode, type OM4, type OFNP

3. Type LC connectors and adaptor panels in rack mounted enclosure

B. UTP Copper Backbone

1. 100-pair Category 3, type CMP

2. Wall-mounted type 110 termination blocks on both ends

3. 24-port, rack mounted Category 6 patch panel on both ends, with Category 6 extension cabling between rear of patch panel and termination bocks.

C. Coaxial Backbone

1. RG11 with quad shield

2. F-connector cable end terminations on both ends

1.4 REFERENCES

A. Refer to Section 271000.

1.5 DEFINITIONS

A. Refer to Section 271000.

1.6 SUBMITTALS

A. Refer to Section 271000.

1.7 WARRANTY AND SERVICES

A. Refer to Section 271000.

PART 2 - PRODUCTS

2.1 FIBER OPTIC CABLE

A. Bulk cable assemblies as follows:

1. 24-fiber single mode cable, type OS2
2. 24-fiber multimode cable, type OM4
3. Type OFNP
4. Interlocking armor sheath construction
5. Yellow outer jacket color for single mode cable
6. Aqua outer jacket color for multimode cable

2.2 FIBER OPTIC TERMINATIONS

A. Fiber Optic Enclosures

1. Designed for 19” rack mounting.
2. Enclosed assemblies designed to protect cables, terminations and subassemblies, equipped with hinged or retractable front and rear covers.

3. Sized to accommodate total installed fiber count plus min. 20% spare capacity.

4. Incorporated duplex type LC adaptor panels mounted within enclosure. Separate adapter panels for each fiber type (single mode and multimode) and for cables serving different basic functions or routed to different locations, with all adaptors labeled accordingly.

5. Adapter panels designed for easy installation, with snap-in front insertion and removal.

6. Provisions for cable strain relief of incoming cables and radius control to limit bend radius of optical fibers to the larger of the manufacturer's recommended minimum or 1.2".

7. Front and rear access to the inside of the enclosure during cable installation, servicing and system administration. Designs that require any disassembly of the enclosure to gain access shall not be accepted.

8. Physical front-rear barrier for protection of both sides of adapter panels, configured to enable only front access when patching, with rear cable terminations inaccessible from the front patching area.

B. Fiber Optic Adapter Panels

1. Snap-in front mounting.

2. Provide blank adaptor panels in any unused panel frame openings to maintain physical barrier between front and rear compartments of enclosure.

3. Color-coded adaptors – blue adaptors for single mode (OS2) cabling and aqua adaptors for multimode (OM4) cabling.

4. All adaptors shall be fitted with dust caps on both ends where not occupied by a fiber optic connector.

5. Maximum insertion loss of 0.75 dB through mated connectors and coupler.

C. Fiber Optic Connectors

1. Small form factor type LC connectors, performance matched to fiber type (OS2 and OM4)

2. Meet or exceed Fiber Optic Connector Intermateability Standards (FOCIS), per (TIA-604-10).

3. Meet or exceed mechanical and environmental performance requirements set forth in the latest edition of TIA-568. Maximum insertion loss shall be 0.75 dB. Minimum return loss shall be 20 dB for multimode and 26 dB for single mode.

4. Connectors shall remain within specifications after sustaining a minimum of 200 mating cycles per TIA-455-21.

2.3 UTP COPPER BACKBONE CABLE

A. Bulk cable assemblies as follows:

1. 100-pair, 24-gauge copper cable
2. Category 3
3. Type CMP
4. 100-ohm characteristic impedance

2.4 UTP COPPER BACKBONE TERMINATIONS

A. Termination Blocks

1. 100-pair type 110 blocks with C4 clips.
2. Min. Category 6 performance rating.
3. Integrated labeling field.
4. Assembly designed for wall mounting.

B. Patch Panels

1. 24-port Category 6
2. Designed for 19” rack mounting.
3. Silk-screened port numbering.

C. Interconnect Cabling

1. Category 6 cable for connection between 24-port rack-mounted patch panel and 100-pair wall-mounted termination block.
2. Min. type CM.
3. Reference Section 271500

2.5 COAXIAL CABLE

A. Plenum-rated type RG-11 with quad shield construction.

2.6 COAXIAL TERMINATIONS

A. Type F cable end connectors – connector body sized for compatibility with cable diameter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pathways and spaces will allow fiber and copper backbone cables to be installed according to manufacturer's recommendations.

B. Verify that cables can be properly supported by cable tray and/or by J-hooks at maximum intervals of four feet along entire cable path.

C. Compare site conditions and construction drawings and notify Architect of any substantial discrepancies.

3.2 INSTALLATION

A. Cable Placement

1. Support cables along entire route with cable tray and/or with J-hooks at maximum intervals of four feet. Secure J-hooks to building structure per manufacturer's recommended methods and applicable codes and standards.

2. Observe manufacturer's stated limits for maximum pulling tension and minimum bend radius at all times for each cable type.

3. Label cable assemblies within 18" of termination points on both ends. For fiber optic cabling, label on outside of rack mounted enclosure, within 18" of penetration into enclosure.

4. Provide a min. 10-foot service loop on both ends of all backbone cable runs. Store spare cable length neatly on ladder rack inside of equipment rooms.

5. Utilize hook and loop fasteners and cable straps to secure cable in place as required. Provide plenum-rated cable straps as required in plenum spaces. Do not tighten straps to the extent of deforming cross-sectional geometry of cable assemblies. Nylon cable ties shall not be permitted.

6. Firestop conduit ends and sleeves penetrating through fire rated structures. Reference Section 271100.

7. Install two-post equipment racks in each telecommunications equipment room as indicated in construction drawings and per approved shop drawings. Locate racks in positions shown to enable proper clearance. Secure all racks to floor with min. 3/8" hardware. Refer to floor plans and rack elevation drawings for placement and panel locations. Ref. Section 271100 for additional requirements.

B. Fiber Optic Cable Termination

1. Mount fiber optic enclosures in equipment racks as indicated in construction drawings and per approved shop drawings.

2. Mount fiber optic adapter panels in enclosure as indicated in construction drawings and per approved shop drawings. Provide blank adapter panels in any unused panel frame openings to maintain physical barrier between front and rear compartments of enclosure.

3. Provide separate adapter panels for single mode and multimode cables and for cables with different basic functions or opposite end locations.

4. Label adapter panels to indicate location of opposite end of cable and as specified in CSCU Telecommunications Infrastructure Standards.

5. Terminate optical fibers using one of the following methods:
   a. Fusion splice factory terminated cable assemblies (pigtails). Individual splice loss shall not exceed 0.2 dB. Mechanical splices shall not be permitted.
   b. Use a fanout kit to secure individual fibers in a protective sleeve, such as an Aramid reinforced tube, and field terminate each fiber with a cable end connector.

6. Provide means for cables and subassemblies to be secured and protected from potential damage.

7. Provide sufficient spare fiber length inside of termination housings to allow for termination and servicing at a 30” high work bench positioned adjacent to the enclosure. In any case, spare fiber length shall be a minimum of 1 meter (39”).

8. Clean connectors and adapters, per industry best practices, prior to mating.

9. Bond metallic armor sheaths to TGB on both ends of cable using appropriate bonding connectors designed for the purpose. Dielectric armor sheaths shall not require bonding.

C. UTP Copper Cable Termination

1. Mount type 110 termination blocks on walls as indicated in construction drawings and per approved shop drawings.

2. Terminate cable on both ends on wall mounted 110 blocks using type C4 clips.

3. Mount 24-port Category 6 patch panels on equipment racks as indicated in construction drawings and per approved shop drawings.

4. At both ends, provide (24) 4-pair Category 6 UTP cables between wall mounted blocks and rack mounted patch panels. At the 110 blocks, terminate each Category 6 cable onto a separate C4 clip. At the patch panels, terminate each Category 6 cable to a separate port. Arrange terminations so that the first patch panel port is linked to the first four pairs of the Category 3 cable; the second patch panel port is linked to pairs 5 through 8; third port to pairs 9 through 12; and so on, until Port 24 of the patch panel is linked to pairs 93 through 96 of the 100-pair Category 3 cable. Pairs 97 through 100 shall not be extended to the equipment rack.

5. Label the 110 block to indicate the patch panel port assignments for each 4-pair group.

D. Coaxial Cable Termination

1. Install type F connectors directly onto both ends of the coaxial cable.

2. Properly strip cable per the connector manufacturer's recommendations.

3. Crimp connector body securely to ensure shield continuity and provide adequate strain relief.

3.3 TESTING

A. Use only test equipment that has been calibrated by the manufacturer or an approved calibration service within the past 12 months prior to use on the project. Proof of recent calibration shall be included with the test report for all test equipment used.

B. Fiber Optic Testing

1. Optical Attenuation shall be measured on all terminated optical fibers, in both directions of transmission, using the "Insertion Loss" method. Measurement shall be taken between fronts of panels on both ends and be inclusive of all optical connectors and adaptors installed within the given fiber optic link. Fiber optic launch cables shall be used at both transmit and receive ends to ensure accurate measurement.

2. Field test instruments for multimode fiber optic cabling shall meet the requirements of ANSI/TIA526-14A. The light source shall meet the launch requirements of ANSI/TIA-455-50-B.3, Method A. This launch condition shall be achieved either within the field test equipment or by use of an external mandrel wrap per ANSI/TIA-568-C.

3. Field test instruments for single mode fiber cabling shall meet the requirements of ANSI/TIA-526-7.

4. The fiber optic launch cables and adapters shall be of high quality and the cables shall not show excessive wear resulting from repetitive field use or coiling and storing.

5. The requirements of the manufacturer of the test equipment shall be observed for all test procedures.

6. The overall Pass or Fail condition for the link under test shall be determined by the results of the individual tests detailed in the following paragraphs.

7. Link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0:
   a. Link Attenuation = Cable_Attn + Connector_Attn + Splice_Attn
   b. Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)
   c. Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)
   d. Splice_Attn (dB) = number of splices (S) * splice_loss (dB)

8. The values to be used for Attenuation_Coefficient shall be as follows:
   a. Single mode: 1.0 dB/km @ 1310 nm and at 1550 nm

b. Multimode: 3.5 dB/km @ 850 nm and 1.5 dB/km @ 1300 nm

9. The maximum allowable value for mated connector_loss shall be 0.70 dB

10. Maximum allowable value for splice_loss shall be 0.2 dB

11. Optical link attenuation measurements shall not include any active devices or passive devices other than cable, connectors, and splices – i.e., link attenuation shall not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

12. Use of test equipment that measures the link length and automatically calculates the link loss based on the above formulas shall be preferred to manual calculation.

13. The above link test limits are based on the use of the One Reference Jumper Method specified by ANSI/TIA-526-14A, Method B and ANSI/TIA-526-7, Method A.1. Procedures established by these standards and related application notes shall be observed in order to accurately conduct performance testing.

14. All backbone links shall be tested in both directions and at both operating wavelengths to account for attenuation deltas associated with wavelength.

15. Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14A.

16. Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation shall be used to determine acceptable values.

17. Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA-526-7. Single mode test equipment shall utilize laser light sources.

18. Provide optical link attenuation (insertion loss) measurements utilizing an optical loss test set employing light sources that meet the launch requirements of ANSI/TIA-455-78-B and TIA-568C.0.

19. All testing shall be performed on the completely installed system, from the front (patch cord side) of the fiber optic patch panel to the front of the corresponding panel on the opposite end of the cable. Disturbance of terminations after testing shall void test results and require re-testing.

C. UTP Testing

1. Provide Category 3 performance certification between corresponding patch panel ports on both ends of the 100-pair Category 3 backbone link.

D. Coaxial Testing

1. Test terminated coaxial cable for continuity and absence of shorts.

3.4 LABELING

A. Provide complete and comprehensive labeling system as specified in the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards.

END OF SECTION

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Sections 271000, 271100 and 271300

C. T-Series set of construction drawings.

D. Applicable portions of the construction documents for other disciplines.

E. All work shall comply with the latest edition of the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards. Where any conflict may exist with this Section or any of the related documents, the requirements of the CSCU standards shall take precedence.

1.2 SECTION INCLUDES

A. Copper horizontal cabling system for network distribution to data outlets and device end points.

1.3 SUMMARY

A. Data Outlet Types

1. Standard: Two (2) Category 6 UTP cables in wall-mounted outlet at 18” AFF

2. Wall-Mounted Wireless Access Point: Two (2) Category 6A STP cables in wall-mounted outlet at 96” AFF

3. Ceiling-Mounted Wireless Access Point: Two (2) Category 6A STP cables in ceiling-mounted outlet at 12” above accessible ceiling

4. Wall-Mounted Telephone Outlet: One (1) Category 6 UTP cable in wall-mounted outlet at 48” AFF

5. Digital Display: Two (2) Category 6A STP cables mounted as prescribed in AV design

B. Patch Panel Fields

1. 48-port Category 6 UTP angled patch panels for all Category 6 UTP cable terminations.

2. 48-port Category 6A STP angled patch panels for all Category 6A STP cable terminations.

3. Horizontal cable managers at top and bottom of patch fields.

1.4 REFERENCES

A. Refer to Section 271000.

1.5 DEFINITIONS

A. Refer to Section 271000.

1.6 SUBMITTALS

A. Refer to Section 271000.

1.7 WARRANTY AND SERVICES

A. Refer to Section 271000.

PART 2 - PRODUCTS

2.1 CABLES

A. Category 6 UTP Cable

1. 4-pair unshielded cable of the 'enhanced' type (often referred to as Category 6e). Minimally compliant cable shall not be accepted. Headroom above TIA Standards for NEXT and PSNEXT shall be at least 3 dB.

2. Constructed with an internal pair separator.

B. Category 6A STP Cable

1. 4-pair cable with an overall shield covering all pairs.

2. Constructed to support Power over Ethernet (PoE) of up to 100 Watts.

C. General

1. Cable assemblies shall be performance verified by an independent testing lab (UL or ETL) and bear the appropriate markings accordingly.

2. All conductors shall be constructed of pure copper. Aluminum clad copper cable shall not be accepted.

3. Cable assemblies shall be plenum-rated, listed type CMP per NEC Article 800, and bear the appropriate markings accordingly.

4. Jacket color shall be coordinated with the Owner.

2.2 JACKS

A. Category 6 UTP and Category 6A STP

1. All jacks types shall be performance verified by an independent testing lab (UL or ETL) and bear the appropriate markings accordingly.

2. For data outlets, jacks shall securely snap into a modular faceplate as part of an integrated outlet assembly.

3. Jack colors shall be coordinated with the Owner.

4. All signal-bearing elements (cables, jacks, patch panels, wiring blocks) of all horizontal cabling links shall be designed and installed to function as a system. The compatibility of the cable with the cable termination components shall be recognized and documented by the manufacturer of the termination components.

2.3 PATCH PANELS

A. Category 6 UTP and Category 6A STP

1. 48-port angled modular patch panels, performance verified by an independent testing lab (UL or ETL) and bearing the appropriate markings accordingly.

2. Designed to enable servicing of terminations and future cable additions without disruption to existing connections.

3. Accommodation for labels on a front for easy port edification.

4. Category 6A STP cables shall be terminated on patch panels designed specifically for STP cabling. STP patch panels shall be properly bonded to the telecommunication grounding and bonding system as prescribed by the manufacturer.

2.4 FACEPLATES

A. Data Outlet Faceplates

1. Faceplates shall be of molded plastic construction and shall be rated per UL 1863 and UL 94V-0.

2. Faceplate design shall incorporate recessed designation strips at the top and bottom of their face surfaces for accommodating identification labels. Designation strips shall be fitted with clear plastic flush covers.

3. Except for wall-mounted telephone outlet faceplates, faceplates shall be single-gang, multi-port models, equipped as necessary with removable blank inserts in all unused jack openings. Blank insert color shall be matched to faceplate color.

4. Wall-mounted telephone outlet faceplates shall be single-gang, single-port metallic models with mounting studs to accommodate the mounting of a telephone directly over the outlet, covering the faceplate.

2.5 PATCH CORDS

A. Category 6 UTP and Category 6A STP patch cords, performance verified by an independent testing lab (UL or ETL) and bearing the appropriate markings accordingly.

B. Snag-free boot design incorporating strain relief.

C. Cable jacket and boot colors and cable lengths shall be coordinated with Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pathways and spaces will allow horizontal cables to be installed according to manufacturer's recommendations.

B. Verify that all horizontal cables can be properly supported by cable tray and/or by J-hooks at maximum intervals of four feet along entire cable path.

C. Compare site conditions and construction drawings and notify Architect of any substantial discrepancies.

3.2 INSTALLATION

A. Cable Placement

1. Provide (2) Category 6 UTP cables to each standard data outlet location.

2. Provide (2) Category 6A STP cables to each wireless access point data outlet.

3. Provide (2) Category 6A STP cables to each digital display data outlet.

4. Provide (1) Category 6 UTP cable to each wall-mounted telephone outlet.

5. Route all data cables to nearest telecommunications equipment room via most direct route following building lines.

6. Prior to placing cable to any given data outlet locations, verify that installed cable length will not exceed 90 m (295 ft.) between termination points on both ends (patch panel and

faceplate). Report any data outlet locations that cannot be reached within this cable distance to the design team for resolution.

7. Avoid kinking, abrasion and other damage to cables during installation.

8. Comply with manufacturer's recommendations for maximum tensile load and minimum bend radius and all times during cable placement.

9. No splices shall be permitted in any cable segment between data outlet and patch panel terminations.

10. Keep cable routing clear of the work of other trades.

11. Support cables according to code utilizing J-hooks or cable wraps anchored to ceiling concrete, walls, piping supports or structural steel beams. Cable support devices shall be designed to limit cable bend radius to 4x cable diameter. Place cable support devices at maximum of intervals of four feet, unless limited by building construction. In any case, if mid-span cable sag exceeds six inches, provide additional support.

12. Do not place cable directly on ceiling grid or ceiling tiles. Do not attach cables to existing cabling, plumbing or steam piping, ductwork, ceiling supports or electrical or communications conduits.

13. Use only plenum-rated hook-and-loop (Velcro-type) fasteners to secure cable bundles.

14. Do not place cable through any conduit or sleeve that is not equipped with protective bushing at all conduit/sleeve openings.

15. To facilitate servicing, provide a one-foot coil of each cable in the ceiling at the last cable support device (e.g., J-hook) before the cables enter the outlet conduit. Secure coil in ceiling to the same last cable support device. For any location where cables are installed in movable partition walls or service poles, increase coiled cable amount to a minimum of 15 feet. In forming cable coils, maintain a minimum inside coil radius of 200% of the cable's recommended minimum bend radius.

16. Avoid placing cable in near proximity to EMI sources. Maintain separation per EIA-568 standards.

17. Route cable bundles neatly and in straight lines and fan cables neatly into patch panel rows and individual patch panel ports.

18. Cable bundles shall not exceed twenty-four (24) cables per bundle.

B. Cable Termination

1. Terminate all Category 6 and Category 6A cables on both ends in compliance with their respective TIA-568 standards and according to the manufacturer's recommendations.

2. For Category 6A cabling, maintain shield continuity through all terminations and bond shields as prescribed by the manufacturer.

3. Ensure that all cables being terminated are free of tension and that no strain will be applied to the terminations.

4. In preparing cables for termination, ensure that all pair twists are maintained to within one-half inch of the insulation displacement contact. Remove cable jackets only to the extent required.

C. Patch Cords

1. Furnish Category 6 UTP and Category 6A STP patch cords to Owner at completion of project.

2. Provide one (1) patch cord for every horizontal cable installed, matching patch cord to cable type – Category 6 UTP vs. Category 6A STP.

3. Coordinate patch cord lengths and jacket colors with owner.

4. Provide machine-printed, self-laminating cable label within three inches of each patch cord end based on the Owner's labeling requirements.

3.3 TESTING

A. Use only test equipment that has been calibrated by the manufacturer or an approved calibration service within the past 12 months prior to use on the project. Proof of recent calibration shall be included with the test report for all test equipment used.

B. All testing shall be performed on the completely installed system. Disturbance of any termination after testing shall invalidate the results for the associated link and require retesting.

C. Test all horizontal cabling links as follows:

1. Conduct testing between modular connection ports of data outlet jack and corresponding patch panel jack.

2. Baseline accuracy of the test equipment shall exceed TIA Level III, as indicated by independent laboratory testing. Test adapter cable shall be approved by the manufacturer of the test equipment.

3. For compatibility with Owner's existing records data base, test equipment used shall be a Fluke DTX Network Cable Tester.

4. The testing performed shall be Permanent Link testing; however, the contractor shall warrant system Channel performance and provide patch cords that meet Channel performance criteria. All cabling not tested strictly in accordance with these requirements shall be retested at no cost to the Owner.

5. Acceptable test data shall indicate that cabling is free of shorts, and shall verify continuity, polarity, and wire mapping.

6. Category 6 and Category 6A parameters tested shall include the following:

a. Length
b. Attenuation
c. Pair to Pair NEXT
d. ACR
e. PSNEXT Loss
f. Return Loss
g. Pair to Pair ELFNEXT Loss
h. PSEFEXT Loss
i. Propagation Delay
j. Delay Skew

7. Category 6A links shall be tested at additional parameters as defined by TIA standards for Category 6A performance.

8. The length measurement for any Permanent Link shall not exceed 90 m (295 ft.).

9. Cables shall be tested to the maximum frequency defined by ANSI/TIA568-C for the respective performance category. For each link tested, the test report shall indicate the overall PASS/FAIL condition, as well as display the specified parameters, indicating measured values relative to acceptable thresholds.

10. Any “Pass*” (with asterisk) or “Warning” indications shall be considered a failure of the tested link. Only “PASS” (without asterisk) indications shall be accepted.

11. Test data shall indicate the worst-case result for each parameter, the frequency at which it occurs, the limits at that point, and the margin. Sweep frequency testing shall be employed, at frequencies and intervals consistent with TIA and ISO requirements.

12. Information shall be provided for all pairs or pair combinations, and in both directions when required by the relevant standards.

D. All test data shall be compiled into a comprehensive certification report and submitted in electronic form. The certification report shall include the following:

1. All test data compiled in alphanumeric order by data outlet number.

2. Copy of certificate of current test equipment calibration.

3. Detailed identification of all test equipment components used, including base and remote test units, adaptors and connecting cables.

4. Diagram of test condition/method used to produce measured data.

3.4 LABELING

A. Provide complete and comprehensive labeling system as specified in the Connecticut State Colleges and Universities (CSCU) Telecommunications Infrastructure Standards.

END OF SECTION

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PART ONE – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the work specified in this Section.

B. Section 012313 Supplemental Bids

C. Coordinate work of this Section with work of other Sections as required to properly execute the Work and as necessary to maintain satisfactory progress of the work of other Sections.

1.2 SCOPE OF SPECIFICATION

A. The following terms are defined for this specification section:

1. "Owner" or "End User" is Norwalk Community College.
2. "Architect" is the Design Architect & Architect of Record for the project: Mitchell/Giurgola Architects, LLP.
3. "Systems" are the audio and video systems.
4. "Designer" or "Systems Designer" is the designer of the audio and video systems: Jaffe Holden.
5. "Electrical Engineer" is the designer of the Electrical Pathway & Wiring Systems: Fletcher Thompson.
6. "Contractor" or "Systems Contractor" is the specialty contractor responsible for the installation of the audio and video systems. Work of the "Systems Contractor" is covered under Supplemental Bid No. 1. Reference Section 01 23 13 Supplemental Bids.
7. "Electrical Contractor" is the specialty contractor responsible for the installation of all electrical pathways (Line & low voltage) and wiring systems (line voltage and higher) as part of the Base Building Contract, working as a subcontractor to the General Contractor.
8. "General Contractor" is the entity responsible for the construction of the facility.

B. This specification covers all Systems as described below for the project. The objective is to provide professional systems, installed, acceptance tested, and ready for use.

C. The written specification and large format drawings AV000 through AV999 shall be collectively referred to herein as the Contract documents. System features which are mentioned in one part may not be shown in the others. In case of conflict between the written specification and the drawings, Contractor must seek clarification from the Systems Designer. In the event that the Contractor fails to obtain such clarification, the interpretation of the Systems Designer will prevail.

1.3 CONTRACTOR RESPONSIBILITY

A. Specification drawings are detailed only to the extent necessary to show design intent and signal flow. It is understood and agreed by the Contractor that the work herein described shall be complete in every detail to supply a complete working system.

B. Equipment not mentioned herein nor shown on drawings but necessary to meet this requirement shall be provided without claim for additional payment.

1.4 SUMMARY DESCRIPTION

A. The following Systems are included in the specification:

1. Student Center Servery & Dining Room AV Systems
2. Theater AV Systems

B. Refer to Appendix A for Complete AV Systems Descriptions

1.5 SCOPE OF WORK

A. Furnish all materials, labor and any engineering services to provide complete and professionally installed Systems in working order as described herein. Labor furnished shall be specialized and experienced in Systems installation.

B. Furnish all back boxes and enclosures.

C. Deliver to the job site all back boxes which are to be installed by other contractor.

D. Furnish and install all wire and cable.

E. Furnish any additional items, not specifically mentioned herein, to meet system requirements as specified, without claim for additional payment. Such items may include hardware, transformers, line/distribution amplifiers and other devices for proper installation, interface, isolation or gain structure.

F. Furnish shop drawings and receive approval, prior to fabrication and installation.

G. Perform initial adjustments and verification tests. Submit verification test report.

H. Participate in acceptance tests and perform final adjustments.

I. Participate in user training.

J. Provide system documentation including copies of all relevant drawings and equipment manuals.

K. Provide maintenance services for the specified period from the date of acceptance.

L. Guarantee all equipment and components for the specified period from the date of acceptance.

M. Requirements and materials that apply to the work of others related to the Systems are listed to define and establish Systems requirements.

N. Work scope does not include the AC power system except as shown in the drawings.

O. Coordination with the Electrical Contractor is required to assure correct Systems conduit routing, Systems backbox locations, and clean power circuit locations as specified in Division 26 - Electrical.

P. See Work Scope Summary Table at the end of Part One (Paragraph 1.13).

1.6 SUBMITTALS

A. Pre-Bid Submittals

1. All Contractors submitting bids for the Systems specified herein must be qualified by the Systems Designer.

2. Not later than ten (10) days prior to the bid date, Contractor shall submit to the Systems Designer for approval, brochures containing a statement of the Contractor's qualifications. At minimum, this submittal shall include the following:

   a. A list of Systems of comparable size and scope to that described herein, completed by the Contractor in the last five (5) years. Indicate the project name and address, year of completion, and the name and phone number of a person to contact who is a representative of the Owner or User.

   b. A personal resume of formal education and experience of the staff member who would act as Leader for the Project

   c. A description of the Contractor's capabilities and facilities for rack assembly, shop fabrication, repair, and servicing of Systems

   d. A description of the Contractor's capabilities and facilities for generating CAD (or other high quality graphics) documentation for the Shop Drawings and As-Built Drawings

3. The following Contractors have submitted the required qualifications and have been approved to bid:

   a. Boston Light & Sound
      290 North Beacon Street
      Boston, MA 02135
      Contact: Zeke Zola
      Phone: 617-787-3131
      Email: zeke@blsi.com

   b. Masque Sound
      21 E. Union Ave.
      East Rutherford, NJ 07073
      Contact: Arno Miller
      Phone: 201-939-8666
      Email: arnomiller@masquesound.com

   c. North American Theatrix
      640 Frederick Rd.
      Catonsville, MD 21228
      Contact: Gary Peck
      Phone: 860-863-4112
      Email: gpeck@natheatrix.com

   d. Onyx AudioVisual
      800 Principal Court, Suite A
      Chesapeake, VA 23320
      Contact: Tom Beaudry
      Phone: 757-436-6116
      Email: tbeaudry@onyxav.com

   e. Professional Audio Designs
      11707-B West Dearbourn Ave
      Wauwatosa, WI 53226
      Contact: Kim Leonard
      Phone: 414-476-1011
      Email: kim@proaudiodesigns.com

f. Pro Sound & Video
300 Maryland Ave NE
Glen Burnie, MD 21060
Contact: Brian Bolly
Phone: 202-796-3100
Email: bbolly@prosound.net

B. Bid Submittals:

1. Contractors shall examine all drawings and read all divisions of this specification in order to avoid omissions and duplications and to ensure a complete job. No allowances shall be made for failure to read and understand these documents. Discrepancies between drawings and specifications or obvious omissions shall be referred to the Systems Designer for clarification before the bid date. Where discrepancies occur and pre-bid instructions have not been obtained, the contractor agrees to abide by the Systems Designer's decision.
2. Bid proposals shall include all work and all equipment as specified, as well as any other equipment and materials to be used in assembling the system.
3. Requests for clarification of specification intent shall be made, in writing, not later than ten (10) days prior to bid date.
4. No portion of the work herein may be assigned or sub-contracted to others unless the following requirements have been satisfied:
   a. The names of any proposed sub-contractors shall have been disclosed in the bid proposal.
   b. A statement of qualifications for each sub-contractor shall have been included with the bid proposal.
   c. All terms of this contract, including bidding and qualification requirements, shall apply to the sub-contractor.
5. The bid submittals shall include the following:
   a. The total Contract price
   b. The total price for any Add Alternates. (See Paragraph 2.02.D)
   c. An itemized list of all equipment and materials to be used in assembling the system
   d. Unit pricing for all items on the specified equipment list
   e. Lot pricing for miscellaneous items not on the specified equipment list
   f. A breakdown of the number of staff hours allotted for:
      (a). Preparation of submittals, shop drawings, and system documentation
      (b). On site coordination meetings and supervision
      (c). In shop engineering, fabrication, and assembly
      (d). On site fabrication, assembly, and installation
      (e). On site verification and acceptance testing

C. Shop Drawing Submittals:

1. Within sixty (60) days after contract award, submit five (5) copies of detailed shop drawings to the Architect for approval. All shop drawings shall be marked with the related drawing number when submitted. Do not begin installation or fabrication without the approval of the Architect and Systems Designer.
2. Review of shop drawings shall not constitute final approval of system function. Said review does not in any way relieve the Contractor from the responsibility of furnishing material or performing work as required by the Contract documents.
3. Failure of the Contractor to submit shop drawings in ample time for evaluation shall not entitle the Contractor to an extension of contract time, and no claim for extension by reason of such default will be allowed.
4. At minimum, the Shop Drawings shall include neatly bound copies of the following:
    a. Table of Contents
    b. Itemized list of all equipment and materials to be used in assembling the system
    c. Catalog cut sheets or data sheets for each listed item
    d. One-line signal flow diagrams for all sound reinforcement and auxiliary systems showing point to point wiring interconnection of all equipment with wire run numbers and patch bay designations. Show all transformers, switches, relays, control circuits, and modifications to equipment. Show all equipment items which are required for realization of the functions described herein.
    e. A complete list of all wire run numbers along with the termination location of each end of each wire run
    f. Detailed 3-wire schematic diagrams for any custom circuitry
    g. Detailed 3-wire schematic diagrams for typical connections between audio lines, patch bays, and rack mounted equipment
    h. Drawings of all items which are to be custom fabricated or modified. Drawings shall be of scale suitable for use in fabrication. They shall show materials, finishes and panel/control markings. Submit samples of lettering/label size and typeface to be employed on custom plates, panels and other equipment.
    i. Full size drawings illustrating the physical layout and labeling of patch bays
    j. Mechanical drawings of all assemblies, major sub-assemblies, racks, cabinets and enclosures
    k. Mechanical drawings showing proposed mounting details of all loudspeakers and associated rigging, and interface with adjacent architecture
5. The above listed drawings shall be produced on AutoCAD or similar computer graphics program. Scans or photocopies of the Systems Designer's specification drawings are not acceptable.
6. The use of electronic files from other sources (e.g., architectural backgrounds, Systems Designer’s drawings, vendor-supplied panel drawings) will not absolve the Contractor of responsibility for ensuring that the Shop Drawings represent a completely engineered, coordinated solution. The Contractor has final responsibility for providing systems which conform to all requirements of this specification.

D. Substitutions:

1. Subsequent to Contract award, substitutions may be permitted, but only with the express written permission of the Systems Designer. The proposed substitutes must be equivalent to the specified products in quality, performance, construction, function and conformance to system objectives.
2. It is the responsibility of the Contractor to prove, to the satisfaction of the Systems Designer, that the proposed substitution is equal to the specified product, as demonstrated by submission of the following:
   a. List of advantages to the Owner
   b. Cost savings
   c. Printed specifications or laboratory test data
   d. Previous field experience
3. The Contractor shall list the unit price of each item proposed for substitution and indicate which specified items are to be deleted.
4. If the Systems Designer determines that the proposed product is not equal to the specified project, the Contractor shall supply the product specified in the Contract documents.
5. Where substitute materials or methods are approved, the Contractor shall make all adjustments to contingent work necessary to accommodate the substituted equipment, without claim for additional payment.
6. In the event that one or more of the products specified herein is unavailable, the Contractor shall make recommendations to the Systems Designer as to what substitutions are available to meet the intent of the specification.
7. The Systems Designer reserves the right to substitute new products which become available subsequent to the issuance of the Contract Documents, provided that:
   a. The Contractor has not yet purchased the originally specified equipment.
   b. The substitute equipment shall not materially increase the Contractor's costs.

E. Samples:

1. Submit samples of substitute equipment to the Systems Designer as required to prove equivalency to items specified.
2. Submit samples of custom work, finishes or other materials as required by the Architect or Systems Designer to verify appearance and quality.
3. Costs for shipping samples shall be the responsibility of the Contractor.

F. Written Guarantee (See Paragraph 1.09)

G. Verification Test Report (See Paragraph 3.13)

H. System Documentation and Operation Manuals (See Paragraph 3.15)

1.7 JOB CONDITIONS

A. Keep the job adequately staffed at all times. Unless illness, loss of personnel or other circumstances beyond the control of the Contractor intervene, keep the same individual in charge throughout.

B. Cooperate with all appropriate parties in order to achieve well coordinated progress with the overall construction completion schedule and satisfactory final results.

C. Watch for conflicts with work of other contractors on the job and execute, without claim for extra payment, moderate moves or changes as are necessary to accommodate other equipment or to preserve acoustic performance, symmetry, and pleasing appearance.

D. Immediately report to the Architect and Systems Designer, any design or installation irregularities, particularly architectural elements that interfere with the intended coverage angles of loudspeakers, so that appropriate action may be taken.

E. Do all cutting, patching and painting for proper and finished installation of the system and repair any damage done as a result of such installation. Clean up and dispose of trash from all Systems work areas.

1.8 QUALITY ASSURANCE

A. Parts listed shall be complete, type numbers accurate and equipment furnished shall conform to manufacturer's specifications.

B. All materials shall be new and shall conform to applicable provisions of Underwriters Laboratories and the American Standards Association.

C. Procure and pay for all permits, licenses and inspections and observe any requirements stipulated therein. Conform in all trades with all local regulations and codes.

D. Comply with federal, state and local labor regulations and applicable union regulations.

E. Installation shall conform to latest federal, state and local electrical and safety codes or those of other authorities having jurisdiction. Where conflicts exist, most stringent code or regulation shall apply.

1.9 GUARANTEE AND SERVICE

A. All systems and components shall be guaranteed free of defects in materials and workmanship for a period of one (1) year from the date of acceptance and shall be repaired or replaced within forty-eight (48) hours following report of such defects by the owner.

B. The Contractor shall be available on call and on eight (8) hour notice during the first month following acceptance of the system, to assist the Owner’s representatives in any problems which may arise during the initial period of operation.

C. If, during the Guarantee period, any component is out of service for more than seven (7) consecutive days due to unavailability of parts or service, Contractor shall supply and install an identical new component. If an identical component is not available, Contractor will substitute equivalent equipment, with the approval of the Owner.

D. During the course of the Guarantee period, the Contractor shall provide a minimum of three (3) service visits to the site for inspection and adjustment of equipment. Contractor shall submit proposed schedule for these visits and shall notify Owner and Systems Designer in writing at least one month in advance of each visit.

1.10 INSURANCE

A. All equipment and materials shall be fully insured against loss or damage up until acceptance of the system by the Owner or until Owner relieves the Contractor in writing of this responsibility, whichever is earlier.

1.11 EXISTING CONDITIONS

A. Visit the site prior to making a bid. No subsequent allowance will be made due to failure to thus observe and verify conditions which may affect the work. Report to the Architect and Systems Designer any discrepancies among this specification and existing conditions and similarly report obvious omissions.

1.12 DEMOLITION

A. All existing system equipment, as well as surface mounted hardware, shall be removed by the Contractor and disposed of as directed by the Owner. System components such as embedded conduit may be abandoned.

1.13 WORK SCOPE SUMMARY TABLE

ITEMS TO BE PROVIDED AND INSTALLED	Electrical Contractor (Base Bid)		Systems Contractor (Supplemental Bid 1)	
	Provide	Install	Provide	Install
Main Power Service Panel Boards and Circuit Breakers	x	x		
Main Power Service Conduit and Conductors	x	x		
Main Power Service Terminations		x		
Audio & Video Technical Power (AVTP) Transformers	x	x		
Transformer Conduit and Conductors	x	x		
Transformer Terminations		x		
AVTP Isolated Ground Conduit and Conductors	x	x		
Isolated Ground Terminations		x◊		
AVTP Distribution Panelboards and Circuit Breakers	x	x		
Distribution Panelboard Conduit and Conductors	x	x		
Distribution Panelboard Terminations		x		
AVTP Standard Load Centers and Circuit Breakers	x	x		
Standard Load Center Conduit and Conductors	x	x		
Standard Load Center Terminations		x		
AVTP Custom Sequencing Panelboards and Circuit Breakers		x	x	
Custom Sequencing Panelboard Conduit and Conductors	x	x		
Custom Sequencing Panelboard Terminations		x◊		
AVTP Company Switches for Portable Equipment	x	x		
Company Switch Conduit and Conductors	x	x		
Company Switch Terminations		x		
AVTP Outlet Devices for Branch Circuits delivered to Systems Equipment Racks and Devices			x	x
Equipment Rack Back Boxes and Wall Plates			x	x
Outlet Device Back Boxes		x	x	
Outlet Device Wall Plates			x	x
Branch Circuit Conduit and Conductors	x	x		
Branch Circuit Termination				x

WORK SCOPE SUMMARY TABLE (continued)

ITEMS TO BE PROVIDED AND INSTALLED	Electrical Contractor		Systems Contractor	
	Pro-vide	Install	Pro-vide	Install
Systems Equipment Racks and Devices			x	x
Metallic Conduit between Systems Devices and Systems Equip-ment Racks	x	x◊		
Conduit Insulation Bushings between Metallic Conduit and Sys-tems Equipment Racks	x	x◊		
Systems Equipment Rack Cabling			x	x
Systems Equipment Rack Terminations				x
Systems Device Back Boxes and Floor Boxes		x◊	x	
Systems Device Metallic Conduit	x	x◊		
Systems Device Cabling			x	x
Systems Device Termination				x
Empty Conduit (for temporary use)	x	x		
Systems Cable Trays	x	x		
Systems Cable Sleeves	x	x		
Systems Pull Boxes	x	x		
Conduit Riser Diagram	x			

◊ Installation criteria to be provided by Systems Contractor

PART TWO - EQUIPMENT

2.1 GENERAL EQUIPMENT

A. Whenever any equipment is specified by manufacturer and model number, it is for purposes of establishing a standard of quality, performance, construction and function.

B. All materials and equipment shall be new and of the latest design or model offered for sale by the manufacturer.

C. Equipment models provided shall operate at the required AC line voltage and frequency.

D. Contractor shall provide quantities as indicated in the equipment list, detail drawings, location drawings, schedule of terminations, and as required for a complete installation.

E. Audio & Video Wire and Cable

1. All wire numbers listed in the drawings are Belden unless otherwise noted.
2. All THHN conductors shall be stranded.
3. Approved manufacturers: Alpha, Belden, Canare, Corning, Gepco, Mogami, West Penn, Whirlwind

F. Electrical Wire and Cable (including grounding conductors):

1. Where conflict exists with any codes or ordinances, such codes and ordinances shall take precedence.
2. Where conflict exists with electrical specifications, the higher standard or more stringent requirement shall apply.

G. Wiring Devices

1. Specifications – Duplex Receptacles
   Grade: Specification, Hubbell IG5362 or equal
   Type: NEMA 5-20R
   Color: Orange
2. Approved Manufacturers: Waber, Wiremold, Hubbell, Bryant, GE, Leviton

H. Electrical Plates and Panels:

1. Specifications – Rack Mount Panels
   Material: 11 gauge steel or 1/8" Aluminum, minimum thickness
   Finish: Black or to match adjacent equipment
   Size: 19" wide, standard EIA mounting hole spacing, height as specified
2. Specifications – Back Box Enclosures
   Material: Code grade steel
   Finish: Black or galvanized
   Size: As specified
3. Specifications – Plug Box and Termination Panels
   Material: 11 gauge steel or 1/8" Aluminum, minimum thickness
   Finish: Black (unless instructed otherwise by Architect)
   Size: As specified

4. Approved Manufacturers: Hoffman, Whirlwind, Pro Co, Wireworks

I. Audio Transformers

1. All transformers shall be selected for proper interface and loading in the circuits as required by as-built conditions and per manufacturer's recommendations.

2.2 MAJOR EQUIPMENT

A. Equipment provided shall be that specified herein or approved substitute (see Paragraph 1.06.D).

B. Detailed performance specifications shall be those published by the manufacturer effective on the date of this document for all equipment listed below.

C. Equipment List

1. Refer to Appendix B for Major Equipment List

2.3 DETAIL DRAWINGS

A. The drawings herein detail custom built equipment and system details.

B. Furnish all materials and labor to provide complete and finished work even though not specifically shown on the drawings.

C. Detail drawings are located in large format drawings AV001 thru AV401T.

PART THREE - EXECUTION

3.1 AUDIO SYSTEM REQUIREMENTS

A. Requirements herein refer to materials and work which are related to or part of the Systems. Where conflict exists with other specifications concerning such work or materials, this specification takes precedence unless otherwise approved in writing by the Owner

3.2 INSTALLATION OF SYSTEMS

A. Locate all apparatus requiring adjustments, cleaning or similar attention so that it will be accessible for such attention. Equipment racks shall be positioned to permit full access for operation and service.

B. Furnish and install brackets, braces and supports. Minimum fastening or support safety factor shall be at least three (3). Design shall be to the approval of the Architect.

C. All supporting structures and enclosures supplied by the Contractor not having a standard factory paint finish shall be painted. Paint specifications will be supplied by the Architect or indicated herein.

D. Provide custom color or finish for any equipment or materials supplied which are exposed to public view. Color and finish of all such equipment or materials shall be approved in writing by the Architect. This does not exclude equipment or materials where standard colors and finishes may be specified herein.

E. Finish of blank panels and custom assembly panels shall match adjacent equipment panels.

F. Switches, connectors, jacks, receptacles, outlets, cables and cable terminations shall be logically and permanently marked. Custom panel nomenclature shall be engraved, etched or screened. Markings for these items are detailed in the drawings to ensure consistency and clarity. Verify any changes in working type size and/or placement with the Systems Designer prior to marking.

G. The equipment specified herein is designed to operate in environments of normal humidity, dust and temperature. Protect equipment and related wiring where extreme environmental conditions can occur.

H. The standard reference for the layout and construction of the system shall be:

Giddings, Philip. *Audio Systems Design and Installation*. Boston: Focal Press, 1990.

3.3 CONDUIT

A. Review and coordinate Systems conduit installation with the electrical contractor to ensure proper operation of the Systems.

B. All wiring shall be in conduit unless authorized by the Architect, approved by the Systems Designer, and permitted by code. Exceptions are short runs at equipment terminations where there is no means of connecting conduit to the equipment.

C. Where installed exposed, conduits shall be parallel with or at right angles to walls or ceilings and shall be supported from walls or ceilings by means of approved galvanized iron clamps or hangers. Conduit connections to equipment racks shall be insulated.

D. Minimum size conduit shall be 3/4 inch. All conduit shall be sized for maximum 40% fill or less if required by code.

3.4 CONDUIT SEPARATION

Systems wiring is divided into wiring groups according to their nominal voltage levels (refer to Schedule of Terminations):

	Wiring Type
Group A	Microphones and other sensitive wiring (0 mV to 100 mV)
Group B	Line level wiring (100 mV to 10 V)
Group C	Loudspeaker and control wiring (10 V to 70 V)
Group D	Telephone, Category Network, video, control and digital circuits
Group E	Fiber optic cable

Note: These wiring groups must never be intermixed within a given conduit run!

A. Minimum conduit separation between conduits carrying wiring of different groups is as follows:

	Group A	Group B	Group C	Group D	Group E
Group A	adjacent	6"	12"	12"	adjacent
Group B	-	adjacent	12"	6"	adjacent
Group C	-	-	adjacent	6"	adjacent
Group D	-	-	-	adjacent	adjacent
Group E	-	-	-	-	adjacent

Note: Ninety degree crossings in close proximity are acceptable.

B. Minimum conduit separation between conduits carrying Systems wiring and other electrical service conduit is as follows:

	Group A	Group B	Group C	Group D	Group E
Dimmer controlled lighting	24"	12"	6"	12"	adjacent
SCR controlled services	24"	12"	6"	12"	adjacent
220/440V circuits	6"	6"	adjacent	adjacent	adjacent
All other services	6"	6"	adjacent	adjacent	adjacent

Note: Heavy current demands in or long parallel runs with the above services may dictate greater separations to avoid interference in the Systems.

C. Contractor shall promptly inform the Systems Designer in writing of conduit installation which does not conform to these requirements.

3.5 ELECTRICAL POWER

A. Review and coordinate electrical power system installation including grounding with the electrical contractor to ensure proper operation of the Systems.

B. Verify that all AC power circuits designated for Systems equipment are wired with correct polarity and isolated ground. Report in writing any discrepancies found to the Architect for corrective action.

C. Provide distribution of electrical power within the equipment racks with a minimum of one spare AC receptacle for each four in use per branch circuit.

3.6 STEEL SUPPORTS

A. Fabricate and install any supports so that the installation does not weaken or overload the building structure. Do not impose the weight of equipment or fixtures on supports provided for other trades or systems. No drilling or cutting of concrete beams, joists, or structural steel, nor welding to structural steel, will be permitted except as authorized, in writing, by the Architect.

3.7 BOXES

A. With the exception of portable equipment, all boxes, conduits, cabinets, equipment and related wiring shall be held in place and the mounting shall be plumb and square.

B. All boxes shall be securely mounted to building structure. All boxes shall be installed so that wiring contained in them is accessible. Install blanking devices or threaded plugs in all unused holes.

C. Wiring groups and circuits shall be isolated as indicated herein. Common pull or junction boxes are not permitted except as authorized, in writing, by the Systems Designer.

D. Clean all box interiors before installing plates, panels or covers.

3.8 WIRING METHODS AND PRACTICES

A. Provide installation of all Systems wire and cable, ensuring proper:

1. Pulling Tensions
2. Quantities
3. Types
4. Lengths
5. Routing
6. Wire Group Separation
7. Identification

B. The interconnection of all equipment requiring shielded cable shall be by Belden type 9451, or equivalent, unless otherwise specified.

C. Spare wire runs of each group and type shall be pulled to each termination location. The number of spares shall be ten percent of those in actual use or one, whichever is greater.

D. Splicing of cables is not permitted between terminations of specified equipment.

E. Do not pull wire or cable through any box fitting or enclosure where change of raceway alignment or direction occurs; do not bend conductors to less than recommended radius. Employ temporary guides, sheaves, and rollers to protect cables from excess tension, abrasion or damaging bending during installation.

F. Provide wire pulling lubricants and pulling tensions in accordance with the wire and cable manufacturer's recommendations.

G. All wires shall be permanently identified at each wire end by marking with adhesive or crimp-on markers and a chart kept of each wire's function. This applies to wire within a rack assembly as well as wire running in conduit.

H. Wire ends should be wrapped with heat shrink tubing. Each shield or drain wire should be covered with heat shrink to avoid unintentional connections.

I. Use ring or tongue lugs on all barrier strip terminals. Do not exceed two lugs per terminal. Use crimping tools which are designed for the application or solder. Do not cut strands from conductors to fit lugs or terminals. Spare terminal blocks, equivalent to 10% of those in actual use, shall be provided.

J. Form, in an orderly manner, all conductors in enclosures and boxes, wire ways and wiring troughs, providing circuit and conductor identification. Tie using tie wraps of appropriate size and type. Limit spacing between ties to six (6) inches and provide circuit and conductor identification at least once in each enclosure.

K. Provide ample service loops at each termination so that plates, panels, patch bays, and equipment can be dismounted for service and inspection.

3.9 GROUNDING

A. Audio system wiring shall conform to the following procedures:

1. Audio equipment AC ground pins shall connect to AC isolated ground.
2. Audio equipment chassis shall connect to AC isolated ground or rack frames.
3. Audio rack frames shall connect to AC isolated ground bus in panelboard by means of #2 gauge (minimum) conductor.
4. Audio shields between AC powered pieces of equipment shall be connected to ground at one end only. Capacitively terminate as required.
5. Audio signal paths between AC powered pieces of equipment shall be connected using balanced lines and/or transformer isolation as required. No unbalanced signal paths may be connected to the patch bay.
6. Isolate all Systems wiring from racks, back boxes and conduit.
7. Isolate all Systems racks from conduit and other conductive surfaces. Use insulated bushings for conduit connections and a dielectric plinth between racks and conductive flooring materials.
8. AC isolated ground system shall be isolated from all other facility grounds.

B. All metallic conduit, boxes and enclosures shall be grounded in accordance with the current National Electrical Code.

C. Metallic enclosures containing active equipment shall be grounded with due regard for the minimization of electrical noise. This may include the provision of grounding conductors separate from the AC ground.

3.10 EQUIPMENT RACKS

A. The equipment racks shall be considered as custom assemblies and shall be assembled, wired and tested in the Contractor's shop. Assembly of racks on-site will not be permitted (except for shielded microphone and line wiring which must connect directly to the patch bays).

B. Placement of equipment in equipment racks, as shown in the drawings, is for maximum operator convenience. Verify any changes in placement of the equipment with the Systems Designer before assembly.

C. Racks shall be installed plumb and square without twists in the frames or variations in level between adjacent racks.

D. All wire, cable, terminal blocks, rack mounted equipment, and active slots of card frame systems shall be clearly and logically labeled as to their function, circuit, or system. Labeling on manufactured equipment shall be by engraved plastic laminate or by thermal printer on adhesive tape, with white lettering on black background or dark background that is similar to panel finish.

E. Provide stiffeners to custom panels to prevent panel deformation during normal plugging or switching operations.

F. All wires and cables used in assembling custom panels and equipment racks shall be formed into harnesses which are tied and supported in accordance with accepted engineering practice.

G. Harnessed cables shall be combed straight, tie-wrapped every six (6) to ten (10) inches, and attached to the structure as necessary. Each cable that breaks out from a harness for termination shall be provided with an ample service loop to permit equipment removal from the racks without disconnecting.

H. Harnessed cables shall be formed in either a vertical or a horizontal relationship to equipment, controls, components or terminations.

I. Cable shields shall be connected to the isolated ground system with due regard for ground loops. (See Giddings reference book, Chapter 10)

J. All system components and related wiring shall be located with due regard for the minimization of induced electro-magnetic and electrostatic noise, for the minimization of wiring length, for proper ventilation, and to provide reasonable safety and convenience for the operator.

K. All rack mounted equipment, with front panel controls, shall be provided with security covers to avoid tampering with preset levels. If specific security covers are not included in the equipment list, the Contractor will provide the manufacturer's security cover for each specified device or a suitable alternate.

L. Every device shall be installed with regard for proper polarity. Absolute polarity shall be maintained through the entire Systems chain.

M. Any electronic device which is connected to the patch bay must be balanced.

3.11 INITIAL ADJUSTMENT

A. Verify all circuits and extensions for correct connection, continuity and polarity. Absolute polarity shall be maintained between all points in the system.

B. Connector polarity shall be maintained except for terminations at equipment manufactured to other standards. In the event that manufactured equipment can be ordered with, or internally set to, various standards, the equipment shall be configured as follows:

1. Polarity for XLR style connector shall be: pin 2-high, pin 3-low, and pin 1-shield.

2. Polarity for TRS style connector shall be: tip-high, ring-low, and sleeve-shield.

C. Make all adjustments and modifications so that the system is operational.

D. Make all adjustments and modifications for system gain structure per recommendations of major component manufacturers.

3.12 VERIFICATION TESTS

A. Confirm that each individual wire and cable run (whether in a rack or in conduit) is identified with a unique number. These numbers are affixed to both ends of each cable and are clearly visible. Provide a complete list of these numbers along with the termination location of each end of the wire run.

B. Confirm that all system outputs are free of spurious signals including oscillations and radio frequency signals. A wide band oscilloscope shall be used to verify this condition.

C. Confirm that the system is free of audible clicks, pops, and other noises when any operating control is activated, with or without input signal.

D. For all microphone lines, tie lines, return lines and effect loudspeaker lines, confirm:

1. Proper circuits appearing at each termination location

2. Proper circuits appearing at each jack bay position

3. Continuity of all conductors

4. Proper polarity is maintained

5. Absence of shorts between conductors within each circuit

6. Absence of shorts between circuit conductors and conduit

E. Confirm that loudspeakers and mountings are free of buzzes and rattles when the loudspeaker is swept with sine wave tones over its rated bandwidth at one-half (1/2) its maximum rated power.

F. For all permanently mounted loudspeaker terminations, provide impedance measurement of each pair of loudspeaker lines with all loudspeakers connected and all amplifiers disconnected. These measurements shall be documented as editable tabular data listing impedance for each 1/3 octave band from 20 Hz to 20 kHz and shall be accurate to the nearest tenth of an Ohm.

G. For all intercom terminations, confirm proper operation by initiating and receiving audio communication and call light.

H. For each installed data network cable or fiber optic cable confirm conformance to the specified TIA/EIA performance standards.

I. For all electronic devices mounted in racks and connected to patch bays, confirm:

1. Every input and output is balanced.

2. Proper polarity is maintained throughout the entire audio path.
3. Tip connection of each TRS jack is connected to the positive terminal of each corresponding input or output.

K. Confirm that there are no shorts between the Neutral and Isolated Ground conductors for each clean power circuit.

3.13 VERIFICATION TEST REPORT

A. Submit written report detailing the results of Initial Adjustments and Verification Tests. Report to include, at minimum, the following:

1. Copies of all relevant drawings, charts, test instrument data, and photographs.
2. PDF copies of all available manufacturers' operation and service literature for each major system component.
3. Written certification that the installation conforms to the requirements stated herein, is complete in all respects, and is ready for inspection, testing, and tuning.

B. This report shall be completed and submitted to the Systems Designer for review a minimum of five (5) days prior to Acceptance Testing and final tuning.

3.14 ACCEPTANCE TESTING

A. Acceptance Testing shall be performed by the Systems Designer during a period designated by the Architect. Contractor shall furnish a minimum of two (2) technicians for the acceptance testing period.

B. The minimum time required for Acceptance Testing is two (2) working days of dedicated quiet for each performance venue and recording studio and two (2) days for the classroom/rehearsal room systems. Coordinate this time period so that free access, work lighting, and electrical power are available on the site.

C. Ensure that Systems areas are in a clean and orderly condition ready for acceptance testing.

D. Provide test equipment (meeting the following minimum specifications) on site, at all times during Acceptance Testing. Prior to Acceptance Testing, provide the Systems Designer with a listing of the specific equipment to be made available.

1. Oscilloscope: 10MHz Bandwidth, Sensitivity – 1mV/cm
2. Digital Multi-meter: 1% Accuracy
3. Function Generator: 1MHz Bandwidth, Distortion < 1%
4. Real Time Analyzer: 1/3 Octave with microphone
5. Pink Noise Source: 20 Hz – 20 kHz Bandwidth
6. Impedance Sweep Meter: 20 Hz – 20 kHz Range, 1 Ohm – 50 kOhm
7. Polarity Checker: Mic, line, or loudspeaker level

Note: Systems Designers may choose to supply their own test equipment.

E. Be prepared to verify the performance of any portion of the system by demonstration, listening tests and instrumented measurements.

F. Make additional mechanical and electrical adjustments within the scope of the work and which are deemed necessary by the Systems Designer as a result of the Acceptance Tests. This may include realigning of loudspeaker systems, changes in system gain structures, grounding, filtering or interfaces.

G. Final acceptance will be contingent upon issuance by the Systems Designer of a letter of acceptance stating that the work has been completed and is in accordance with the contract documents.

H. Contractor will bear any costs incurred for additional Systems Designer's time and expenses due to failure to have the system functioning in accordance with specification requirements at the times scheduled for Systems Designer's Acceptance Testing and tuning.

3.15 SYSTEM DOCUMENTATION

A. Within thirty (30) days of the Acceptance Testing, prepare and submit a CD-ROM of the preliminary Operation and Maintenance manual for approval by the Systems Designer. Manual to include, at minimum, the following documents in PDF format:

1. Table of contents
2. Written Guarantee and service policy
3. Basic power on/off and operational procedure
4. Copies of all shop drawings which have been updated to include any changes made during the installation process
5. All available manufacturers' operation and service literature for each major system component
6. One line signal flow diagram with all cable runs and patch points identified by alpha-numeric character
7. Copy of the Verification Test report
8. Copy of conduit riser diagram
9. Copy of the final tuning settings as provided by the Systems Designer

B. Systems Designer will review the above system documentation. Upon approval, Contractor shall prepare and submit to the Owner:

1. Five (5) copies of the final Operation and Maintenance manual on CD-ROM or Flash Disk
2. Two (2) hard copies of the final Operation and Maintenance manual printed and neatly bound

C. Provide framed copy of the as-built signal flow diagram to be mounted in the control room. This diagram shall have all cable runs and patch points identified by alpha-numeric character.

END OF SECTION 274100

AUDIO VIDEO SYSTEMS FUNCTIONAL SYSTEMS DESICRPTION

INTRODUCTION

This document outlines the AV system criteria for the programmed spaces for the Norwalk Community College project, specifically: Theater and Eatery & Dining Hall. This report will offer a general overview of the AV systems included within each Performance of the facility. Project specific solutions and details will be developed in the coming phases as the design progresses.

The AV systems have been designed from programming documentation and discussion with the end users, providing a highly flexible yet easy to use series of systems. These systems are designed to operate 24 hours a day, 7 days a week, and to facilitate continuous and simultaneous use, be it for performance or rehearsal need.

The facility is designed as a comprehensive, multi-use arts space suitable for conceptually derived productions, or outside rentals. As such, the AV Systems are designed for flexibility and interconnectivity between the various performance spaces, allowing each to operate autonomously or together as one building should the need arise.

To facilitate understanding, the document is broken down into sections as per the Programming documents. These sections are as follows:

Part Description

1. Facility Wide Systems
2. Public & Support Spaces
3. Theater
4. Dining Hall & Servery

1 - FACILITY WIDE SYSTEMS

The Theater is designed as a fully integrated facility for the theatre arts. To achieve this goal, many of the AV technical systems are interconnected, allowing fluid exchange of audio and video material for performance and pedagogical use. Systems that overlap operation, as well as systems that bridge performance venues in front-of-house and back-of-house areas are described below:

Isolated Ground for AV systems

The Theater audio and video systems utilize a separate Audio & Video Technical Power system (AVTP) to ensure noise-free operation. The AVTP system runs on a dedicated transformer and all associated outlets utilize dedicated isolated ground wires and hospital-grade outlets. The AVTP system is used only for audio and video equipment. The AVTP System also includes stage disconnects (company switches) in major performance spaces to facilitate outside events. Design of system and location of transformer (and if it is several) to be coordinated with the EE. Note: The Dining Hall systems are not part of the AVTP Isolated Power system.

Portable Equipment (FF&E)

The Theater and Dining Hall contain portable equipment for performance and presentational use. Equipment can include: microphones, cables, microphone stands, direct boxes, monitor loudspeakers.

2 – PUBLIC & SUPPORT SPACES

Lobby

Lobbies for performance spaces include monitoring capability (audio and video) to the adjacent performance hall. Video displays for digital signage, and latecomer show-relay are positioned adjacent to each performance space.

Digital Signage

Public displays use for latecomer show-relay can also select to view digital signage feeds used to inform, engage, and solicit patrons.

Front-of-House Support

The front-of-house support spaces have production intercom capabilities and selectable program and page feeds from the performance venues, allowing staff to monitor and communicate with backstage and stage management personnel as required. Designated front-of-house support spaces are as follows:

- Box Office

Back of House Corridors

BOH Corridors contain loudspeakers for the selectable show relay and technical paging. The default settings will correspond to the adjacent venue, but can be changed as program requires.

Dressing/Changing Rooms

Each of the dressing rooms contains selectable program/page feeds from the Theater. This system provides audio relay of activities taking place within the halls, and can accept stage manager page. Green Rooms also contain a video display, allowing technical video to be patched to the room for production viewing.

3 – Theater

Performance Audio System

The audio system is designed to fill multiple requirements – subtle voice lift for lectures and drama, moderately higher outputs for reinforced music, full-bandwidth audio for cinema screening and controlled vocal imaging and sound effects for musical theater.

- Left/center/right ("LCR") main loudspeakers are installed above and around the proscenium to provide the majority of sound to the audience.
- Supplemental loudspeakers extend the reach and frequency content of the LCR arrays. Typically these supplemental loudspeakers are from the same manufacturer as the main arrays to help facilitate uniform voicing.
    - Left and right subwoofers extend low-frequency content for music and effects. These are integrated with the main left and right arrays.
    - Over-audience fills ensure uniform coverage at the margins of the main array coverage.
- Connections for surround-sound effects and monitor loudspeakers are provided around the stage, in the catwalks and around the seating areas. These are used to connect portable loudspeakers, as needed.
- Connections for microphones and other input devices are provided around the stage and in the catwalks.
- A portable mixing area will be located in the audience chamber. This allows for in-house mixing of audio-critical shows (musical theatre and popular music events) with minimal loss of seats or sightline issues.

Presentation Audio System

For modest and quick presentation need, the theater control system features the ability to control selected aspects of the Audio system via the touch-panel interface of the control system. This allows for users to easily walk in and activate sources for events, without necessarily requiring technical assistance from the support team. The audio levels are also controlled via auto-mixing within the DSP, allowing users limited control while maintaining the system at optimum levels without going into feed-back. Input sources include:

- Installed wireless microphones
- Designated Audio receptacles
- Video switcher (for program material from video sources)

Typical Manufacturers:

- DSP Control: BSS
- Microphones: Shure

- Loudspeakers: L-Acoustics

Hearing Assistance System

This system transmits stage sound or other selected program material by means of infrared or radio frequency carrier to individual receivers provided for the hearing impaired. Alternate uses of the infrared system include transmission of a second language or of audio descriptions for the sight impaired. Typical manufacturer: Listen Technologies

Intercom System

A multi-channel intercom system in installed with connection points located throughout the stage and support spaces. This system allows the connection of wired beltpacks for production communication use. A stage manager station is also included, allowing the stage manager to communicate with all intercom channels, as well as page to BOH areas. Typical manufacturer: Clear Com

Live Room Microphone System

A stereo microphone suspended in the audience chamber picks up signals from all performances, both amplified and unamplified. Signals from this source are distributed to a number of auxiliary systems, including hearing assistance, intercom, and the Program/Page Matrix. In addition, this source can be used to feed an archival recording system.

Production Video

Video functions include production camera distribution for show run requirements

- A permanent high-resolution camera is provided mounted above the control room window, along with a lower-resolution camera capable of infrared imaging through use of an infrared illuminator.
- Connections for portable video (for temporary displays and camera locations) are provided around the stage and orchestra pit, in the catwalks and around the seating areas. These are used to connect portable devices, as needed.
- Fiber-Optic Interconnections will be available to connect video and broadcast feeds to and from the TV Studio

Presentation Video Projection System

Primary video presentation within the theater is through a high-definition and high-brightness video projector, located within the control booth. This projector fires onto a roll-down projection screen, located at the apron of the stage. Video source selection is through a video matrix switcher, allowing designated connection points, and video playback gear (Blu-Ray, or streaming appliance) to be selected (through the control system) for display on the projection screen. Source locations include:

- DSL & DSR AV Panel – each of these AV panel contains a "video transmitter", allowing the connection of user computers via HDMI or VGA. The transmitter sends the signal to the video switcher via shielded network cabling.
- Control Booth Connection – The Control booth rack contains a "video transmitter", allowing the connection of user computers via HDMI or VGA. The transmitter sends the signal to the video switcher via shielded network cabling.

Typical Manufacturers:

- Video Switching: Extron
- Projector: Barco
- Screen: Da-Lite

Control System

The Theater features an installed control system to allow users easy access to the primary functions of the AV system, including: Audio System control; Video source selection; projector & screen control. The user interface is through one of two (2) touch-panels – one proposed to be located backstage left, and one located within the control booth. Protected by a pin number password, the panel can be accessed by authorized users to activate various aspects of the AV system on different pages of the touch-panel. Functionality includes:

- AV System Power On & Off
- One-Touch activation of Projector & screen (though independent control is always available)
- Source Selection for Video Switcher
- Audio Source & level control (wireless microphones, video switcher audio, and designated microphone jacks)

Typical Manufacturer: Extron touch-panel control system, or Campus Standard.

Theater Booth and Rack Rooms

- The control booth houses live mixing and playback equipment, including:
  - A medium format digital mixing console. This console can be relocated to the house mix position (see above) when needed.
  - Playback and recording on CD as well as hard-disk based effects playback.
  - The primary patch-bays used to interconnect the various input and output locations around the theater.
  - Booth audio, including monitoring for the audio and lighting operators and the stage manager.
- An audio rack room is provided for:

- The digital signal processors ("DSP") used to time align, "tune" and control the main loudspeaker systems. These devices are selected for compatibility with the primary mix console and loudspeakers.
- Control and processing for the auxiliary systems, which includes ADA-compliant listening assistance, production intercom and backstage and lobby program and paging systems (see also below).
- The video distribution and patching systems.
- Amplifiers for the main and auxiliary audio systems.

Dressing/Changing Rooms

The dressing rooms and corridors contain loudspeakers for the monitoring of stage activities. These rooms have discreet volume controls, however an SM Page override system circumvents local control, allowing pages from the stage manager to always go through.

5 – Dining Hall & Servery

The Dining Hall space is intended for student dining use, along with planned presentation activities in the off-hours. The system is designed for one-touch operation, allowing users of all skill levels ease of control over the AV systems. The AV systems are served by a control rack located in the storage room next to the Servery.

Presentation Video Projection System
Primary video presentation within the Dining Hall is through dual high-definition and brightness video projectors, located on the South Wall cross-beam. These projectors fire onto roll-down projection screens, above the banquets on the North Wall. These projection screens also utilize line-shaft winches, allowing the screen to be deployed lower into the room. Video source selection is through a video matrix switcher, allowing designated connection points, and video playback gear (Blu-Ray, or streaming appliance) to be selected (through the control system) for display on the projection screen. Source locations include:

- Floor Left/Center/Right – each of these AV panel contains a "video transmitter", allowing the connection of user computers via HDMI or VGA. The transmitter sends the signal to the video switcher via shielded network cabling.
- Control Position – In the North-East corner, below the touch-panel is an AV panel that contains a "video transmitter", allowing the connection of user computers via HDMI or VGA. The transmitter sends the signal to the video switcher via shielded network cabling.

Typical Manufacturers:

- Video Switching: Extron
- Projectors: Christie
- Screens: Da-Lite

Presentation Audio System
For modest and quick presentation need, the Dining Hall control system features the ability to control selected aspects of the Audio system via the touch-panel interface of the control system. This allows for users to easily walk in and activate sources for events, without necessarily requiring technical assistance from the support team. The audio levels are also controlled via auto-mixing within the DSP, allowing users limited control while maintaining the system at optimum levels without going into feed-back. In addition, the Audio System contains ADA provisions for Assistive Listening System, with an appropriate antenna provided on the wall. Input sources include:

- Installed wireless microphones
- Designated Audio receptacles
- Video switcher (for program material from video sources)

Typical Manufacturers:

- DSP Control: BSS
- Wireless Microphones: Shure

- Loudspeakers: In-Ceiling

Control System

The Dining Hall features an installed control system to allow users easy access to the primary functions of the AV system, including: Audio System control; Video source selection; projector & screen control. The user interface is through the touch-panes, located in the North-East corner of the Dining Hall. Protected by a pin number password, the panel can be accessed by authorized users to activate various aspects of the AV system on different pages of the touch-panel. Functionality includes:

- AV System Power On & Off
- One-Touch activation of Projectors & screens (though independent control is always available)
- Source Selection for Video Switcher
- Audio Source & level control (wireless microphones, video switcher audio, and designated microphone jacks)

Typical Manufacturer: Extron touch-panel control system.

Servery

The Servery contains several digital signage displays, to be utilized for menu-board applications as well as the NCC campus-wide digital signage system. The following locations are included:

- Within Servery – Three individual displays are located above food preparation areas. Each display has a signage player for menu-board content.
- South Hallway – A single display is located in the corridor south of the Servery, for playback of Servery announcements, as well as NCC campus wide digital signage.
- Dining Hall – A single display is located in the South-East Corner of the Dining Hall, for playback of Servery announcements, as well as NCC campus wide digital signage.

Typical Manufacturers: Displays – Samsung; Signage Players – MediaStar, or as per food service vendor.

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274100 - APPENDIX B - MAJOR EQUIPMENT LIST

Theater System

Device	MFR	Model	QTY
Stage Interface			
Termination - Offstage Input	Custom	Per drawing AA	2
Termination - Upstage Input	Custom	Per drawing AB	1
Termination - Downstage Input	Custom	Per drawing AC	1
Termination - Broadcast Camera	Custom	Per drawing AF	2
Termination - House Aux Input	Custom	Per drawing AG	2
Termination - FOH Aux Input	Custom	Per drawing AK	1
Termination - Audio Control	Custom	Per drawing AL	1
Termination - Room Mic	Custom	Per drawing AM	1
Termination - Assisted Listening Antenna	Custom	Per drawing AN	1
Termination - Wireless Microphone Antenna	Custom	Per drawing AO	2
Termination - Video Projector	Custom	Per drawing AP	1
Termination - Camera Input	Custom	Per drawing AQ	1
Termination - Projection Screen	Custom	Per drawing AR	1
Termination - Booth Stage Manager Input	Custom	Per drawing AS	1
Termination - Tech Table Position	Custom	Per drawing AT	1
Termination - Forum Panel	Custom	Per drawing AU	1
Termination - Control Touchpanel	Custom	Per drawing AX	1
Termination - Loudspeaker Array	Custom	Per drawing BA	3
Termination - Stage Monitor Loudspeaker	Custom	Per drawing BE	2
Room Microphone	Shure	VP88	1
OR	*Audio Technica*		1
OR	*Schoeps*		1
Mic Mounting Assembly	Custom	As Required	1
B&W Camera with lens (IR)	Marshall	C-1070	1
OR	*Panasonic*		1
OR	*Sony*		1
Illuminator	Bosch	UFLED95-9BD	1
OR	*Illuminar*		1
OR	*Axton*		1
PTZ Camera	Sony	SRG300SE	1
OR	*Panasonic*		1
OR	*Vaddio*		1
Camera Mounting Assembly	Custom	As Required	2
Loudspeakers			
Array Loudspeakers	L-Acoustics	Focus	3
OR	*Meyer*		3
OR	*D&B*		3
Array Loudspeakers	L-Acoustics	Wide	6
OR	*Meyer*		6
OR	*D&B*		6
Sub	L-Acoustics	SB18m	2
OR	*Meyer*		2
OR	*D&B*		2
Array Amplifier	L-Acoustics	LA4X	3
OR	*Meyer*		3

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OR	*D&B*		3
Array Loudspeaker Mounting	L-Acoustics	by Contractor	3
OR	*Meyer*		3
OR	*D&B*		3
FX/MON Loudspeakers	L-Acoustics	5XT	4
OR	*Meyer*		4
OR	*D&B*		4
FX/MON Loudspeakers	L-Acoustics	X8	4
OR	*Meyer*		4
OR	*D&B*		4
Monitor Wedge	L-Acoustics	X12	2
OR	*Meyer*		2
OR	*D&B*		2
FX/MON Amplifier	L-Acoustics	LA4X	2
OR	*Meyer*		2
OR	*D&B*		2
Stage Monitor Loudspeakers	QSC	E12	2
OR	*EAW*		2
OR	*D&B*		2
Stage Monitor Loudspeaker Amplifier	Yamaha	PX10	1
OR	*QSC*		1
OR	*Powersoft*		1
FX/MON Output Assign Panel	Custom	by Contractor	1
Equipment Rack			
Hub – Auditorium Equipment Rack	Custom	Per drawing ZA	1
OR	*Sanus*		1
OR	*Winsted*		1
Stagebox - Cat-6 MADI 48 channel XLR input	Soundcraft	Compact Stagebox	1
OR	*Yamaha*		1
OR	*Digico*		1
Stagebox - Dante Card	Soundcraft	ViO-DANTE	1
OR	*Yamaha*		1
OR	*Digico*		1
Computer (Rackmount, Dual NIC)	By Contractor	$800 Allowance	1
Rack Keyboard/Trackpad	Middle Atlantic	RM-KB	1
OR	*Sanus*		1
OR	*Winsted*		1
24" Touch LCD Monitor, WUXGA Resolution, VESA Mount Capable	By Contractor	$300 Allowance	1
Monitor Mount	Middle Atlantic	RM-LCD-PNLK	1
OR	*Sanus*		1
OR	*Winsted*		1
Control Switch	Cisco	SF300-24P	1
OR	*Aruba*		1
OR	*Extreme Networking*		1
Dante A Switch	Cisco	SG300-10	1
OR	*Aruba*		1
OR	*Extreme Networking*		1
Dante B Switch	Cisco	SG300-10	1

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OR	*Aruba*		1
OR	*Extreme Networking*		1
ULXD Quad Receiver	Shure	ULXD4Q	1
OR	*Sennheiser*		1
OR	*Lectrosonics*		1
Handheld Transmitter	Shure	ULXD2/B58	4
OR	*Sennheiser*		4
OR	*Lectrosonics*		4
Lavalier Microphone	Countryman	B3	4
OR	*DPA*		4
OR	*Audix*		4
Directional Antenna	Shure	UA874	2
OR	*Sennheiser*		2
OR	*Lectrosonics*		2
Antenna distribution	Shure	UA844SWB	1
OR	*Sennheiser*		1
OR	*Lectrosonics*		1
Control System Processor	Extron	IPCP Pro 350	1
OR	*AMX*		1
OR	*Crestron*		1
Video Distribution Amplifier (1x8)	Blackmagic	CONVMSDIDA	2
OR	*Extron*		2
OR	*Datavideo*		2
Black Burst Generator	Blackmagic	CONVMSYNC	1
OR	*Extron*		1
OR	*Datavideo*		1
Video Switch (2x1)	Kramer	VS-211HDXL	1
OR	*Extron*		1
OR	*Blackmagic*		1
Camera Distribution Amplifier (1x8)	Blackmagic	CONVMSDIDA	1
OR	*Extron*		1
OR	*Datavideo*		1
Audio Embedder	AJA	3G-AMA	1
OR	*Extron*		1
OR	*Blackmagic*		1
DSP 1	BSS	BLU-806	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
AES Output Card	BSS	Digital Output	2
OR	*QSC Qsys*		2
OR	*Symetrix*		2
Analog Input Card	BSS	Analog Input	2
OR	*QSC Qsys*		2
OR	*Symetrix*		2
DSP 2	BSS	BLU-120	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
Analog Input Card	BSS	Analog Input	2
OR	*QSC Qsys*		2

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OR	*Symetrix*		2
Analog Output Card	BSS	Analog Output	2
OR	*QSC Qsys*		2
OR	*Symetrix*		2
DSP 3	BSS	BLU-120	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
Analog Input Card	BSS	Analog Input	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
Analog Output Card	BSS	Analog Output	3
OR	*QSC Qsys*		3
OR	*Symetrix*		3
Streaming Player	Apple	AppleTV	1
Video Matrix	Extron	Crosspoint 84 4K	1
OR	*Analog Way*		1
OR	*Barco*		1
BOH Program Amplifier	Extron	XPA2002	1
OR	*QSC Qsys*		1
OR	*Yamaha*		1
24 VDC Power Supply - Program Priority Override	Custom	by Contractor	1
RF Transmitter and Supply	Listen Technologies	LT-800-216	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
Transmitter Rack Mount	Listen Technologies	LA-326	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
Remote Antenna	Listen Technologies	LA-117	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
RF Receiver	Listen Technologies	LR-4200-216	12
OR	*Sennheiser*		12
OR	*Williams Sound*		12
RF Headphones	Listen Technologies	LA-403	12
OR	*Sennheiser*		12
OR	*Williams Sound*		12
RF Neck Induction Loop	Listen Technologies	LA-430	3
OR	*Sennheiser*		3
OR	*Williams Sound*		3
Charging Case - 12 Units	Listen Technologies	LA-380	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
DTP to HDMI Receiver	Extron	DTP HDMI 4K 330 RX	3
OR	*Crestron*		3
OR	*AMX*		3
DTP Transmitter (panels AA, AS)	Extron	DTP T UWP 232 D	3
OR	*Crestron*		3
OR	*AMX*		3
Rack Panel – Accessory Receptacle Panel	Custom	Per Drawing AV030	1

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Projector	Barco	F90-W13	1
OR	*Digital Projection*		1
OR	*Christie*		1
Projector Lens FLD 2.37-3.79:1 EN14	Barco	R9801209	1
OR	*Digital Projection*		1
OR	*Christie*		1
DTP to HDMI Receiver (Projector)	Extron	DTP HDMI 4K 330 RX	1
OR	*Crestron*		1
OR	*AMX*		1
Projection Screen 120" x 192", 16:10 Ratio, Tensioned Roll Down Projection Screen, include low voltage control	Da-Lite	Wireline Advantage with HD Progressive 0.9 surface	1
OR	*Stewart*		1
OR	*Draper*		1
Touchpanel Backstage	Extron	TLP Pro 1020M	1
OR	*Crestron*		1
OR	*AMX*		1
Touchpanel Booth Tabletop	Extron	TLP Pro 720T	1
OR	*Crestron*		1
OR	*AMX*		1
Patchbay - Audio	Audio Accessories	WEP-262EO-SH-JSK	3
OR	*Neutrik*		3
OR	*Whirlwind*		3
Patchbay - Coax	Canare	26DV-2U	1
OR	*Bittree*		1
OR	*ADC-Commscope*		1
Patchpanel - Cat/Fiber	By Contractor	Contractor Proposed	A/R
Patch Cable – Shielded Cat-6 2ft	By Contractor	Contractor Proposed	12
Patch Cable – Coax 2ft	Canare	VPC Series - Yellow	12
OR	*Bittree*		12
OR	*ADC-Commscope*		12
Patch Cable - Fiber	By Contractor	Contractor Proposed	A/R
Patch Cable – 1’	Audio Accessories	621B	10
OR	*Neutrik*		10
OR	*Whirlwind*		10
Patch Cable – 2’	Audio Accessories	622A	40
OR	*Neutrik*		40
OR	*Whirlwind*		40
Patch Cable – 3’	Audio Accessories	623D	6
OR	*Neutrik*		6
OR	*Whirlwind*		6
Mult Box 25' 12 Channel XLR F to G Block with Broadway Clips	Wireworks	Linebox	1
OR	*Whirlwind*		1
OR	*Proco*		1
Mult Box 50' 12 Channel XLR F to G Block with Broadway Clips	Wireworks	Linebox	1
OR	*Whirlwind*		1
OR	*Proco*		1
Patch Cable Holder	Audio Accessories	PCH-X	1

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OR	*Middle Atlantic*		1
OR	*Raxxess*		1
Drawer	Middle Atlantic	D4	APD
OR	*Sanus*		APD
OR	*Winsted*		APD
UPS	Ametek	UPS-2000-OL	1
OR	*Middle Atlantic*		1
OR	*APC*		1
Front of House			
Mixing Console	Soundcraft	Vi2000	1
OR	*Yamaha*		1
OR	*Digico*		1
Stage Lectern			
Touchpanel Tabletop	Extron	TLP Pro 720M	1
OR	*AMX*		1
OR	*Crestron*		1
Lectern Video Switch	Extron	DTP T DSW 4K 233	1
OR	*AMX*		1
OR	*Crestron*		1
Lectern Video Auto-switch/Transmitter	Extron	DTP T UWP 332 D	1
OR	*AMX*		1
OR	*Crestron*		1
Video receiver (loose)	Extron	DTP HDMI 4K 230 Rx	1
OR	*AMX*		1
OR	*Crestron*		1
Lectern (Furniture)	TBD	$4000 allowance	1
Lectern Monitor	TBD	TBD	1
Lectern connection cable	Custom	by Contractor	1
Intercom			
Remote Station - 4 Channel	Clearcom	RS-702	1
OR	*RTS*		1
OR	*Riedel*		1
Power Supply	Clearcom	PS-704	1
OR	*RTS*		1
OR	*Riedel*		1
Termination - Intercom Receptacle	Custom	Per drawing AI	12
Backstage Audio & Video			
Backstage Loudspeaker & Xformer & Baffle Round with Enclosure	JBL	Control 16C/T	15
OR	*QSC*		15
OR	*Soundtube*		15
Stage Support Loudspaeker and Enclosure	Atlas	SBMS	6
OR	*QSC*		6
OR	*Soundtube*		6
BOH Volume Control	Atlas	AT35-PA	8
Green Room Display	Samsung	DM55	1
OR	*NEC*		1
OR	*LG*		1
FOH Displays	Samsung	DH55	2

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OR	*NEC*		2
OR	*LG*		2
SDI to HDMI Converter	AJA	Hi5-Plus	3
OR	*Blackmagic*		3
OR	*Extron*		3
Termination - Video Display	Custom	Per drawing AH	3
Termination - Volume Control	Custom	Per drawing AV	8
Termination - Backstage Ceiling Loudspeaker	Custom	Per drawing BB	15
Termination - Stage Support Ceiling Loudspeaker	Custom	Per drawing BC	6
Stage Manager Rack & Portable Rack			
Portable Rack	Gator	G-Tour 8U	1
OR	*SKB*		1
OR	*Hafer Cases*		1
Power Distribution	MAP	PD-915R-PL	1
OR	*Juice Goose*		1
OR	*Furman*		1
Rack Light	LittLite	RL-10-D-LED	1
Gooseneck microphone	Clock Audio	D33 E	1
OR	*Shure*		1
OR	*Audio Technica*		1
Intercom	ClearCom	RM-704	1
OR	*RTS*		1
OR	*Riedel*		1
SM Control Panel	BSS	Contrio EC-4B	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
SM Control Panel Mount (with button panel & XLR for page mic)	Custom	by Controactor	1
Portable SM VID Rack	Gator	G-Tour EFX4	1
OR	*SKB*		1
OR	*Hafer Cases*		1
Video Display	Elvid	SRM-7x2-LT	1
OR	*Marshall*		1
OR	*Tote Vision*		1
Blank Panel	MAP	1U Blank	1
OR	*Sanus*		1
OR	*Winsted*		1
Loose Equipment			
Microphone Stand 17-25in & Boom 18-30in	Konig & Meyer	25900-577-55	2
OR	*Atlas*		2
OR	*Ultimate Support*		2
Microphone Stand 35-63in & Boom 18-30in	Konig & Meyer	21090-577-55	8
OR	*Atlas*		8
OR	*Ultimate Support*		8
Microphone Stand 44-79in & Boom 42in	Konig & Meyer	21021-577-55	2
OR	*Atlas*		2
OR	*Ultimate Support*		2
Microphone Stand 34-62in	Atlas	MS-12CE	4
OR	*Ultimate Support*		4
OR	*Konig & Meyer*		4

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Microphone Stand 38-62in	Atlas	MS-25E	2
OR	*Ultimate Support*		2
OR	*Konig & Meyer*		2
Microphone Case	SKB	SKB-1200	1
OR	*Gator*		1
OR	*Grundorf*		1
Microphone Cable – 10’	Whirlwind	JHA-QMC-10F	10
OR	*Canare*		10
OR	*Mogami*		10
Microphone Cable – 20’	Whirlwind	JHA-QMC-20F	15
OR	*Canare*		15
OR	*Mogami*		15
Microphone Cable – 50’	Whirlwind	JHA-QMC-50F	4
OR	*Canare*		4
OR	*Mogami*		4
Microphone Cable – 100’	Whirlwind	JHA-QMC-100F	2
OR	*Canare*		2
OR	*Mogami*		2
Loudspeaker Cable – 25’	Whirlwind	JHA-NL4-25F	8
OR	*Canare*		8
OR	*Mogami*		8
Loudspeaker Cable – 50’	Whirlwind	JHA-NL4-50F	4
OR	*Canare*		4
OR	*Mogami*		4
Loudspeaker Cable Adapter	Whirlwind	NL4MMX	4
OR	*Canare*		4
OR	*Mogami*		4
Audio Adapter Kit	Remote Audio	APPKITPRO	1
OR	*Whirlwind*		1
OR	*Neutrik*		1
Microphone – Piano	DPA	VO4099P Kit	1
OR	*Schoeps*		1
OR	*Neumann*		1
Microphone – Dynamic Inst	Shure	SM57-LC	4
OR	*Neumann*		4
OR	*AKG*		4
Microphone – Dynamic Vocal	Shure	SM58-LC	4
OR	*Neumann*		4
OR	*AKG*		4
Microphone – Condenser Vocal	Shure	KSM9/CG	2
OR	*Neumann*		2
OR	*AKG*		2
Microphone – Condenser Small Dia.	Shure	SM81-LC	2
OR	*Neumann*		2
OR	*AKG*		2
Microphone – Condenser Large Dia	Shure	KSM32	2
OR	*Neumann*		2
OR	*AKG*		2
Microphone – Condenser Micro Dia	Shure	Beta98AD/C	4
OR	*Neumann*		4

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OR	*AKG*		4
Microphone – Large Instrument A	Shure	Beta56	2
OR	*Neumann*		2
OR	*AKG*		2
Microphone – Large Instrument B	Shure	Beta52	1
OR	*Neumann*		1
OR	*AKG*		1
Direct Box	Radial Engineering	J48	4
OR	*Whirlwind*		4
OR	*BSS*		4
Direct Box Cable	Whirlwind	L06	4
OR	*Canare*		4
OR	*Mogami*		4
Direct Box	Whirlwind	PCDI	1
OR	*Radial Engineering*		1
OR	*BSS*		1

Dining and Servery

Device	MFR	Model	QTY
System Interface			
Termination - Input Connection	Custom	Per drawing FF	3
Termination - Wall Input Connection	Custom	Per drawing FG	1
Equipment Rack			
Hub – Dining and Eatery Equipment Rack	MAP	SR-40-28	1
OR	*Sanus*		1
OR	*Winsted*		1
UPS	Ametek	UPS-2000-OL	1
OR	*Middle Atlantic*		1
OR	*APC*		1
DSP	BSS	BLU100-2600	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
DSP	BSS	BLU-BIB	1
OR	*QSC Qsys*		1
OR	*Symetrix*		1
Amplifier	CROWN	Dci 8/300	1
OR	*QSC*		1
OR	*Powersoft*		1
Amplifier	CROWN	Dci 2/300	1
OR	*QSC*		1
OR	*Powersoft*		1
Patchpannel	Custom	Per Drawing ZF	2
Patch Cable - Shielded Cat-6 2ft	By Contractor	Contractor Proposed	8
Patch Cable holder	Audio Accessories	PCH-X	1
OR	*Middle Atlantic*		1
OR	*Raxxess*		1
Drawer	MAP	D2	1
OR	*Sanus*		1
OR	*Winsted*		1
ADA Compliant RF System			

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RF Transmitter and Supply	Listen Technologies	LT-800-216	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
Transmitter Rack Mount	Listen Technologies	LA-326	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
Remote Antenna	Listen Technologies	LA-117	1
OR	*Sennheiser*		1
OR	*Williams Sound*		1
RF Receiver	Listen Technologies	LR-4200-216	24
OR	*Sennheiser*		24
OR	*Williams Sound*		24
RF Headphones	Listen Technologies	LA-403	24
OR	*Sennheiser*		24
OR	*Williams Sound*		24
RF Neck Induction Loop	Listen Technologies	LA-430	5
OR	*Sennheiser*		5
OR	*Williams Sound*		5
Charging Case - 12 Units	Listen Technologies	LA-380	2
OR	*Sennheiser*		2
OR	*Williams Sound*		2
Termination - Assisted Listening Antenna	Custom	Per drawing FN	1
Wireless Microphones (Installed in Equipment Rack)			
ULXD Quad Receiver	Shure	ULXD4Q	1
OR	*Sennheiser*		1
OR	*Lectrosonics*		1
Handheld Transmitter	Shure	ULXD2/B58	4
OR	*Sennheiser*		4
OR	*Lectrosonics*		4
Bodypack Transmitter	Shure	ULXD1	4
OR	*Sennheiser*		4
OR	*Lectrosonics*		4
Lavalier Microphone	Countryman	B3	4
OR	*DPA*		4
OR	*Audix*		4
Directional Antenna	Shure	UA864US	2
OR	*Sennheiser*		2
OR	*Lectrosonics*		2
Termination - Wireless Microphone Antenna	Custom	Per drawing FO	2
Projection System			
Projector	Christie	D13WU-HS	2
OR	*Barco*		2
OR	*Digital Projection*		2
Projector Lens FLD 2.37-3.79:1 EN14	Christie	2.0-4.0:1	2
OR	*Barco*		2
OR	*Digital Projection*		2
Projector Mounting	Custom	by Contractor	2

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Projection Screen 120" x 192", 16:10 Ratio, Tensioned Roll Down Projection Screen, include low voltage control	Da-Lite	Wireline Advantage with HD Progressive 0.9 surface	2
OR	*Draper*		2
OR	*Stewart*		2
Termination - Projector Connection	Custom	Per drawing FP	2
Termination - Projector Screen & Lift	Custom	Per drawing FS	2
Control System			
Video Matrix	Extron	Crosspoint 82 4K	1
OR	*AMX*		1
OR	*Crestron*		1
DTP to HDMI Receiver	Extron	DTP HDMI 4K 230 Rx	2
OR	*AMX*		2
OR	*Crestron*		2
DTP Transmitter	Extron	DTP T UWP 332 D	4
OR	*AMX*		4
OR	*Crestron*		4
HDMI to Fiber Transmitter	Extron	Foxbox Tx HDMI	2
OR	*AMX*		2
OR	*Crestron*		2
Fiber to HDMI Receiver	Extron	Foxbox Rx HDMI	2
OR	*AMX*		2
OR	*Crestron*		2
Extron Control	Extron	IPCP Pro 350	1
OR	*AMX*		1
OR	*Crestron*		1
Control Switch (POE)	Juniper	EX2200-C	1
OR	*Cisco*		1
OR	*Aruba*		1
Touchpanel	Extron	TLP Pro 1020M	1
OR	*AMX*		1
OR	*Crestron*		1
Termination - Touchpanel	Custom	Per drawing FX	1
Displays and Signage			
Display (Hallway)	Samsung	DM55	1
OR	*NEC*		1
OR	*LG*		1
Display (Dining)	Samsung	DH55	1
OR	*NEC*		1
OR	*LG*		1
Display (Servery)	Samsung	DH48	3
OR	*NEC*		3
OR	*LG*		3
Servery Signage Mount - Large Flat Panel Ceiling Mount	Chief	Fusion Large (LCM)	3
OR	*Peerless*		3
OR	*Premier*		3
Signage Player (Servery - Determined by Vendor)	TBD	$1500 allowance/display	3
Termination - Video Display	Custom	Per drawing FH	2

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Termination - Servery Display	Custom	Per drawing FJ	3
Loudspeakers			
Termination - Ceiling Loudspeaker	Custom	Per drawing GA	10
Loudspeaker	JBL	Control 321C	10
OR	*QSC*		10
OR	*Soundtube*		10
Wireless Microphones (Portable-Shared by both Spaces)			
ULXD Quad Receiver	Shure	ULXD4Q	1
OR	*Sennheiser*		1
OR	*Lectrosonics*		1
Handheld Transmitter	Shure	ULXD2/B58	4
OR	*Sennheiser*		4
OR	*Lectrosonics*		4
Bodypack Transmitter	Shure	ULXD1	4
OR	*Sennheiser*		4
OR	*Lectrosonics*		4
Lavalier Microphone	Countryman	B3	4
OR	*DPA*		4
OR	*Audix*		4
Severy Loose Equipment Severy			
Microphone Stand 35-63in & Boom 18-30in	Konig & Meyer	21090-577-55	2
OR	*Atlas*		2
OR	*Ultimate Support*		2
Microphone Stand 34-62in	Atlas	MS-12CE	2
OR	*Ultimate Support*		2
OR	*Konig & Meyer*		2

End of 274100 Appendix B

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Pull Cord Switch

B. Visual Lamp with buzzer

C. Transformer

D. Flasher

1.3 RELATED SECTIONS

A. Division 26: Electrical wiring requirements.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Submit shop drawings for all equipment.

PART 2 - PRODUCTS

A. MANUFACTURERS

1) Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a) Aiphone.
b) Edwards Signaling.
c) TekTone.

2.2 GENERAL

A. Provide a complete system of conduits, wire and cable, outlet boxes and equipment to produce a complete Toilet Emergency Call System.

B. Equipment shall be as follows (basis of design is Edwards Signaling):

1) Pull Cord - Edwards #7302 or approved equal.

2) Emergency Lamp - Edwards #7633-4 or approved equal.

3) Transformer - Edwards #88-100 or approved equal (plug-in type not allowed).

4) Flasher - Edwards #7490-A or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Flush mount pull cord switch 36” AFF next to toilet.

B. Except as indicated otherwise semi-flush mount visual/audible device centered above door frame.

C. Conceal the transformer and flasher in NEMA 1 metal enclosure above ceiling.

D. Obtain 120V power form local receptacle circuit.

END OF SECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES

A. Pathways.

B. Security cabling.

C. Cable connecting hardware.

D. Cabling system identification products.

E. Description

1. The awarded installation contractor of this section shall furnish and install all the cabling indicated within the architectural drawings associated with the Intrusion detection system and all access control devices associated with the secured doors.
2. Electronic safety and security equipment coordination and installation.
3. Common electronic safety and security installation requirements.

1.3 DEFINITIONS

A. “Project Manager” shall mean the Owner’s appointed representative.

B. “As Necessary” shall mean work which is required for completed construction, but is not necessarily shown or described in the Contract Documents.

C. “As Required” shall mean work which is required for completed construction and is shown on the drawings or described in the project specification.

D. “Install” shall mean to set in place complete with all mounting facilities and connections as required ready for normal use of service.

E. “Substantial Completion” shall mean that the project is sufficiently complete to be utilized for its intended use as stated in the body of this written specification.

F. “Conduit” shall include all fittings, sleeves, connections, hangers and other accessories related to such conduit.

G. "Surface Metal Raceway" shall include all fittings, sleeves, connections, hangers and other accessories related to such raceway.

H. "Concealed" shall mean hidden from sight, as in chases, furred spaces, shafts, fixed ceiling or embedded in construction.

I. "Exposed", shall mean not "concealed" as defined above.

J. "Governmental" shall mean all municipal, state and federal government agencies.

K. The words "Furnish", "Supply" and "Provide" shall mean purchase, deliver to the job site, protect and provide interim storage and install in accordance with manufacturer's specifications.

L. Words "Approved Equal" shall mean any product which in the opinion of the Technology Consultant is equal in quality, arrangement, appearance, and performance to the product specified.

M. "Cabling" shall mean cable assembly, raceway, conductors, fittings and any other necessary accessories to make a complete wiring system.

N. "Product" shall mean any item of equipment, material, fixture, apparatus, appliance or accessory installed under this Division.

O. Words in the singular shall also mean and include the plural, wherever the context so indicates, and words in the plural shall mean the singular, wherever the context so indicates.

P. "Contractor" refers to the biding/installation Contractor responsible for furnishing and installation of all work indicated within this specification.

1.4 SECURITY CABLING DESCRIPTION

A. Security cable and its connecting hardware provide the means of transporting signals between the remote security devices and the main hardware located within the communications equipment rooms.

1.5 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. Product Data: For each type of product indicated and utilized.

C. Qualification Data: For Installer**,** qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Codes and Standards:

1. All materials and workmanship shall comply with the latest additions of all applicable Codes, Specifications, Local and State Ordinances and Industry Standards.

2. The Contractor shall promptly notify the Construction Manager in case of conflict between Building Codes, State Laws, Local Ordinances and the Contract Documents.

3. Should the Contractor perform any work that does not comply with the requirements of the applicable Building Codes, Local Ordinances and Industry Standards, they shall bear all costs arising in correcting the deficiencies.

4. The Contractor, for the work in their scope, shall give all necessary notices, obtain all permits, pay all governmental taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. The Contractor shall obtain all required Certificates of Inspection for his respective work and deliver same to the Construction Manager before request for acceptance of their work is made and before final payment.

1.7 COORDINATION

A. Coordinate layout and installation of security pathways and cabling with Owner's telecommunications and LAN equipment and Security service suppliers.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Belden CDT Inc. Electronics Division.
2. West Penn.
3. Approved Equivalent.

B. Cabling size and conductor quantities are described within the architectural drawing package.

2.2 SLEEVE SEALS

A. Sleeves shall be adequately sized for the conduits and cables to be installed, with sufficient free space to install sealing caulk or putty. All sleeves will be fabricated of 1" minimum O.D. EMT, de-burred, material with a plastic or metal collar securely fastened to each end.

B. Where penetrations are within floor slabs and fire rated partitions, pack the annular space between the sleeves and the conduit or cables with fire-retardant putty. The sealant material shall be intumescent, asbestos free and installed in accordance with UL and the manufacturer's instructions.

C. Fire-retardant sealer and system shall be UL listed for the application and meet ASTM E-84, ASTM E-814, and UL 1479 requirements. Use Nelson "FSP" or approved equal.

D. If Contractor elects to utilize any penetration which may currently exist, then it is the Contractors responsibility to properly sleeve and firestop that penetration prior to completion of project.

2.3 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

B. All conduits etc., passing through fire rated floors, walls and partitions, shall have the space between the raceways, sleeves and all penetrations filled with a reusable fire stopping material such as Firestop Putty, Adhesive Firestop Sealant or Firestop Compound as manufactured by STI or approved equal.

2.4 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. All security cabling shall be labeled at both ends.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Testing: Continuity of cabling shall be performed and test results submitted to the Owner.

PART 3 - EXECUTION

3.1 All locations shown on the Architectural drawings are for approximation purposes only and must be field verified prior to installation. 10' service loops are required to enable terminations subsequent to device installation.

END OF SECTION

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS & INFORMATION

A. General provisions of the Agreement, including the College of Connecticut "Standard Instructions to Bidders" and "Minimum Insurance Requirements".

B. Security Drawings: SC.01S, SC.02, SC-02S, SC.01T, SC.02T, SC-RIS & SEC-DET, SEC-DET2;

1.2 PROJECT SUMMARY

Phase III of the Norwalk Community College Master Plan consists of the expansion and renovation of the existing cafeteria to convert it into a Student Center for the College's West campus. Another part of this final phase will be to renovate the East Campus building's existing Theater to serve and support the most current information technology resources for education and student performing arts.

These security system specifications are issued as it relates to providing the security devices such as card access system field panels, the low voltage power supplies, the card readers, door position switches and request to exit devices. The electrified door hardware will be provided and installed by others. The electrical conduit and back box infrastructure to support the installation of the security system devices was provided by others. The head-end Verint video management system including all the recorders and monitors are existing. The IP cameras will be provided and installed by others under a separate contract.

The College has recently adopted the RS2 security access control and security monitoring system as their standard on campus. The head-end RS2 system was installed as part of the Phase I project on the East campus. The RS2 system will be capable of monitoring and controlling alarm points and access control points through the use of distributed intelligent electronic intelligent field panels (IFPs). The contractor for this Phase III project will be responsible to interface with the existing campus system.

All bidders for this final master plan project must be certified dealers/integrators for the RS2 system. Bidders are required to provide documentation that the contractor is an authorized dealer for all products proposed and provide lists of contractor's staff that have been factory trained on the major systems being proposed.

The security systems for the campus shall be monitored and controlled from a centralized Security Operations Center (SOC) on campus with a location to be determined.

The communication between the existing RS2 system's server the intelligent field panels within this building that control the card readers and electrified door hardware shall reside on the campus IT network.

The RS2 access control system shall have the capability of monitoring alarm conditions generated by intrusion detection devices. All perimeter doors of this building shall be monitored with door position switches. Most of the perimeter doors as part of this project shall also be provided with electrified hardware to allow for automatic control (locking and unlocking) through the future SMS system.

The campus Video Management System (VMS) (PROVIDED BY OTHERS) shall consist of IP cameras and network video recorders (NVR). The IP cameras shall be recorded on NVRs to be located centrally on campus. The College has standardized on the Verint VMS for their campus surveillance solution and currently has about 200 IP cameras connected to it. The recorded or live video for viewing at the NVR workstation shall be transmitted via the campus network. The color IP cameras scheduled for the building shall primarily located at the exits and pedestrian entrances of the facility as well as at the lobbies and common open areas within each facility. The IP cameras shall be powered via the network utilizing CAT 6 cable.

Bidders are required to provide documentation that the contractor is an authorized dealer for all products proposed and provide lists of contractor's staff that have been factory trained on the major systems being proposed.

1.3 SECURITY SYSTEM DESCRIPTION

This section provides a general description of the security work to be performed. Specific requirements are described in following sections.

A. Security Management System (SMS)

The College has recently adopted the RS2 security access control and security monitoring system as their standard on campus. The head-end RS2 system was installed as part of the Phase I project on the East campus.
.

B. Video Management System (VMS) (PROVIDED BY OTHERS)

Provide IP cameras shall use industry standard video compression protocols. The campus Video Management System (VMS) shall consist of IP cameras and network video recorders (NVR). The IP cameras shall be recorded on NVRs to be located centrally on campus. The College has standardized on the Verint VMS current version 6.4.2.

C Communication System

New IP video cameras and the SMS smart panels shall communicate with the head end servers and recorders via the NCC campus network.

Security contractor shall be responsible to interface the College's IT department personnel to assure a fully operational security transmission system.

D. Manufacturers and Equipment Selection

Where a single manufacturer is listed in these specifications for a specific component, alternates may only be proposed after written approval by Owner prior to bid.

In all cases, it is the bidder's responsibility to ensure that proposed equipment will meet the functional and performance requirements. Any exceptions must be stated clearly in the relevant proposal section.

1.4 WORK INCLUDED

A. Submit shop drawings, samples, training plan, testing plan, as-built drawings, operations manuals, and maintenance manuals. Attend site coordination meetings.

B. Within two weeks of contract award, develop a project implementation schedule and coordinate the timeline with that of the general construction schedule. Create a project matrix based on the security implementation schedule which shall be updated and distributed weekly. The project matrix shall be reviewed via scheduled conference calls with the security project team or during a site meeting if necessary. The conference calls shall be scheduled at least monthly to insure timely reporting of any issues relative to installation progress or coordination, but may be required more frequently due to critical schedule or coordination issues.

C. Train security system operators, administrators, and supervisors in the complete operation of the system.

D. Commissioning: collect, develop, prepare and enter all initial database information including, but not limited to employee access data, alarm descriptors, alarm response messages, report styles, on-screen camera titles, video switching, and video recording schemes. Contractor shall submit to Owner suitable data entry forms within one week of bid award and shall instruct Owner on what data is required to complete the forms.

E. Test and debug all cable and associated components, sub-systems, and systems. Resolve defective items until complete acceptance by Owner. (Beneficial use shall not be considered acceptance).

F. Warrant and maintain system for one year from date of system acceptance. Provide pricing for comprehensive maintenance for 2nd through 5th years with this proposal).

G. Supply and install all specified equipment and low voltage cable. Terminate and tag all cabling. Connect security equipment to the building's power (convenience receptacles and plug-in transformers shall not be used).

H. Security contractor shall supply and install "local" conduit for equipment enclosures and power supplies in the IT closets. All power shall be hard-wired and all cable shall be concealed in metal conduit (and/or EMT) or raceway. Cabling for each security system component to the IT closets shall be via IT cable trays (provided by others).

I. Supply, install, wire and connect low voltage power transformers and power supplies for field panels, door locks, cameras, card readers, etc. Install, connect and test fire alarm interrupt relays to specified lock power supplies.

J. Supply and install low voltage power supplies (24 VDC) for the electrified door hardware (hardware by others).

K. Supply and install all standard and custom security equipment back boxes. Supply and install conduit, conduit stub-ups, pull boxes, junction boxes, termination boxes and back boxes. Metal conduit shall be installed where cable would otherwise be exposed, and as required by code. For dry wall construction, conduit may be limited to stub-ups from equipment back boxes to junction boxes within drop ceilings. Use of any type of raceway other than metal conduit is forbidden unless specifically approved by the Owner.

L. Attend site coordination meetings. Interface with the campus NCC IT department and their contractors to coordinate the integration between the security communication components and the communication components for the campus network.

M. These specifications describe major components. The intent of this procurement is to assure a complete working system to be installed. Contractor shall furnish and install components as described plus all necessary items (e.g., connectors, jumpers, mounting hardware, etc.) to achieve the intent.

N. The security contractor shall be responsible under this contract for all electrical and installation work described above. Electrical subcontractors shall be subject to Owner approval.

1.5 WORK BY OTHERS

A. For connectivity from the building to the central servers and recorders will be provided by others. The security contractor shall be responsible to interface with NCC IT department personnel to assure a fully operational security transmission system.

B. Electric door locking hardware and power transfer hinges shall be provided and installed by the Architectural Door Hardware supplier.

C. Conduit, conduit stub-ups, riser sleeves, cable tray with "J" hooks, pull boxes, and back boxes shall be supplied and installed under separate electrical contract. Metal conduit shall be used where cable would otherwise be exposed, and as required by code. For dry wall construction, conduit may be limited to stub-ups from equipment back boxes to junction boxes within drop ceilings.

D. Installation, connection and testing of fire-alarm lock-power interrupt relays shall be provided at each IFP location (security closets) under the fire alarm system contract.

E. Fire resistant, ¾", 4'x8' plywood backboards for security equipment at the IT closet locations shall be supplied and installed by others. Each closet location shall be provided with necessary 110 VAC 20 amp power both standard house power for fail-safe locks and UPS and generator for other security system elements.

1.6 RELATED SECTIONS

A. Electrical- Section
B. Architectural Doors- Sections 08100, 08110, 08120, 08300, 08330, 08450 & 08710.
C. Electrical

1.7 SUBMITTALS

A. Shop Drawings

Within three (3) weeks of contract award, submit three (3) sets of the following for approval as ONE complete package. Submittal shall be rejected if items are missing.

1. List of all items being submitted.

2. Description of operation.

3. Technical specification data sheets for all items. Indicate specific model number and options on sheets covering multiple models and options. (NOTE: providing cut sheets with initial proposal does not acquit contractor of this requirement)

4. Samples of all exposed equipment and mounting hardware.

5. Plans showing device locations and cable/conduit routing.

6. Riser diagrams showing interconnections.

7. Detail drawings showing installation and mounting.

8. Wiring diagrams.

9. Point-to-point termination schedules.

10. All drawings shall be fully dimensioned and prepared in AutoCAD V.2010 compatible format. Contractor shall use the current version of the SIA/IAPSC CAD Security Symbols (V3.0 Oct. 2015).Construction documents in .dxf or .dwg format will be made available on diskette to the successful contractor.

11. Unless otherwise instructed, contractor should not order any equipment until approvals have been granted. Contractor shall identify in proposal any long lead-time items that will require early approval.

12. Compile and provide a list of deficiencies noted or missing infra-structure, interfaces, door hardware, power, network/fiber optic cable, etc. for correction by the associated discipline.

13. Acceptance of shop drawings shall not relieve contractor from compliance with these specifications. The check of shop drawings is for review of general conformance and compliance with the design concept of the project. Contractor shall remain responsible for meeting all the requirements of the contract documents, including the correlation of all quantities and dimensions; the selection of fabrication processes and techniques of construction; the coordination of work with other trades; and the performance of all work in a safe and satisfactory manner.

B. <u>As-Built Drawings</u>

One copy of the following shall be compiled into one (1) Operating and Maintenance Manual and shall be submitted for approval. A drawing set refers to items 5 though 10 listed above.

1. Operating manual.

2. Maintenance manual.

3. Configuration Manual:
   a. Configuration diagrams
   b. As-built capacities and field expansion capabilities
   c. Operating system and software configuration
   d. Application software manual.

4. Full size, reproducible drawing set.

5. Full size set of blue or black line drawings.

Once approval has been granted, submit three (3) complete sets of the above documentation to the Owner. Documentation shall reflect the as-built and as-approved condition of the system. With the approved documentation, submit to Owner all drawing files on CD ROM in AutoCAD V.2010 .dwg or compatible .dxf format. Contractor shall use the current version of the SIA/IAPSC CAD Security Symbols (V3.0 Oct. 2015).

1.8 WARRANTY

A. Security contractor shall warrant the installed system and the software to be free of defects of materials and workmanship for a period of one-year following the date of system acceptance by Owner. System acceptance shall be when all parts, components, sub-systems and systems have been tested and shown to be working in accordance with the specification and all record drawings have been approved.

B. During the warranty period any components, features or performance found not to meet these specifications shall be corrected at no additional cost to the Owner. This shall be regardless of any acceptance of shop drawings, as-built drawings or systems, unless their exception has been accepted in writing as part of the contractor's proposal and contract.

C. During the warranty period and as part of the warranty service, provide maintenance as described in 1.9.

1.9 MAINTENANCE

A. The bidder shall offer a complete contract maintenance service through a local repair shop capable of meeting the performance specifications described below. Contractor shall provide documentation to show that service engineers have been factory trained on the equipment that will be installed.

B. The contractor shall propose a comprehensive maintenance contract to cover the services described in Sections C & D below for a minimum of 4 years following the end of the warranty period (total 5 years from the date of system acceptance).

C. Provide the following services:

1. Emergency maintenance service shall be rendered within 4 hours of notification of emergency. (Emergency service shall be required if a system sub-system, device, or component failure requires the posting of additional security staff to maintain an equivalent security level.)

2. Non-emergency repair requests shall be rendered within 24 hours.

3. Replace defective parts and components as required and as described in Section D below.

4. Maintain manufacturer's software with upgrades of "fixes", "patches", and all new versions that have been released for at least one year.

5. Incorporate improved system reliability, as it becomes available.

6. Perform regularly scheduled preventive maintenance quarterly. This shall include cleaning of exposed equipment (e.g., lenses), adjustments, etc., and shall include a 100% field device inspection and test. Submit quarterly test and maintenance reports to Owner with documentation of all routine and emergency maintenance procedures performed during the prior period.

D. Replacement Parts.

1. The bidder shall maintain or shall have availability of replacement parts. An ample stock of components shall be carried or available for as long a period as demand warrants. This period shall extend well beyond the normal life expectancy of the equipment.

2. If original parts are no longer available, Owner shall be notified and shall have the choice of having the part replaced with the most current equivalent part, or of having all similar installed parts replaced with the most current equivalent part, at no cost to the Owner.

3. Any device that cannot be repaired on-site within 4 hours of arrival of the service representative shall be immediately replaced with a replacement device in good working order. Owner's device shall be re-installed when its repairs are complete.

4. Any part that cannot be repaired shall be replaced with a new part of the same make and model as the original.

1.10 COMMISSIONING

A. The contractor shall be responsible for the collection, development and inputting of all data required by the system at start-up. The contractor shall submit to the Owner, within two weeks of contract award, such forms as are necessary for the Owner to determine what data is to be included, e.g. student, employee records (name, phone no., vehicle plate number, social security number, access level), alarm point descriptors, door propped alarm time delays, camera descriptors, etc. The contractor shall provide the Owner such instruction as may be required to intelligently make such selections.

B. Commissioning shall include the following:

1. Collecting and inputting alarm zone and point descriptors, required operator response texts, standard and custom database and report styles.

1.11 CODES AND STANDARDS

All components, sub-systems and the implemented systems shall comply with all national, local and state codes, including but not limited to the following:

1. Local Building Codes.
2. NFPA-70, NEC-2004 (National Electrical Code)
3. NFPA-101, Life Safety Code.
4. American with Disabilities Act (ADA).
5. Underwriter Laboratory (UL).
6. Occupational Health and Safety Association requirements (OSHA).
7. National Electrical Contractors Association/National Electrical Installation Standards (NECA/NEIS).

1.12 PROPOSAL

Prospective contractors shall provide all data requested below in a clear and concise format. If data is missing, Owner shall have the option of disqualifying the proposal.

A. Provide a pricing sheet with unit material and labor costs, quantities and totals for all items. Manufacturer, model number, options, and finish/color shall identify all equipment items. Unit pricing shall include first year warranty and first year maintenance as described above and be valid for Adds and Deletes.

A. Include separate line items for duties, license fees, bonds, insurance, etc.

B. Include line item pricing for each sub-contractor (identify by name), and for commissioning, testing, training, drawing submittals, and other services.

C. Provide separate price for maintenance contract for years 2, 3, 4, and 5.

D. Provide catalog sheets for all equipment. Where sheets cover multiple models and/or options, clearly indicate which model and/or options are proposed. Include one blank sample and one photo sample of the proposed access control card/badge.

E. Provide a written certification that the proposed products and services will meet these specifications. Clearly indicate any exceptions and/or substitutions with the reasons, cost implications, and benefits to the Owner. If specific exceptions are not indicated, it shall be assumed that the contractor shall comply with all aspects of these specifications. Security applications software shall be the standard, off-the-shelf products of the original manufacturer/supplier and shall be supplied complete with necessary use license and documentation. Bidders shall describe in the Technical Proposal the software version number; date issued, and list of end users for that version number (minimum 5). Custom, alpha or beta versions of the software shall not be acceptable. Contractors shall be required to disclose any restrictive codes, which may have been placed in the software to make it inoperable.

F. Provide documentation that contractor is an authorized dealer for all products proposed and provide lists of contractor's staff who have been factory trained on the major systems being proposed.

G. Provide a list of five installations of similar size that the contractor has completed with similar equipment over the last three years. Provide details of size, complexity, major equipment manufacturer make and model numbers, and client references with current phone numbers.

H. Provide a best estimate implementation schedule from contract award through system acceptance. Indicate critical tasks and tasks that rely on input, supply, or coordination with others. Identify any long lead purchase or fabricated items that require early shop drawing approvals.

I. Describe any equipment or services that are required but are not included in either your proposal or in the "Work by Others" section. Describe any site space requirements.

J. Provide one (1) original and four (4) copies of the proposal.

PART 2 - PRODUCT- ACCESS CONTROL/ALARM MONITORING (AC/AM)

2.1 SCOPE

A. As part of another project, the College is in the process of designing and implementing a new Security Management System (SMS) for the campus access control and security monitoring functions. The system will be capable of monitoring and controlling alarm points and access control points through the use of distributed intelligent electronic intelligent field panels (IFPs).

.

2.2 OPERATION

A. The new system will be capable of monitoring and controlling alarm points and access control points through the use of distributed intelligent electronic intelligent field panels (IFPs).

2.3 MATERIAL

A. Cable and Conduit

1. Provide cable in accordance with manufacturer's specification.

2. Cable shall be installed in rigid metal conduit for vertical stub-ups, where exposed, and where required by code. Use of any type of raceway other than rigid metal conduit is forbidden unless specifically approved by the Owner.

3. All cable shall be plenum rated where required by code.

B. Identification and Tagging

1. Labels, tags or other permanent markings shall be used to identify all cables, wires, terminal blocks and terminals. All markings shall clearly indicate the function, source and destination.

2. All identifications, markings, and labeling shall be clearly shown on as-built drawings.

GENERAL FEATURES

A. The new system will be capable of monitoring and controlling alarm points and access control points through the use of distributed intelligent electronic intelligent field panels (IFPs).

2.5 SYSTEM EQUIPMENT & COMPONENTS

A. Main AC/AM System

The College has recently adopted the RS2 security access control and security monitoring system as their standard on campus. The head-end RS2 system was installed as part of the Phase I project on the East campus. The RS2 system will be capable of monitoring and controlling alarm points and access control points through the use of distributed intelligent electronic intelligent field panels (IFPs.

B. Card Reader

1. No access compromise shall be possible from circuitry accessible from within the reader. All critical circuitry shall be located within a secured area.

2. Reader system equipment shall operate as specified in environments of electromagnetic, radio frequency, and spurious electrical power line interference.

3. Reader shall be compatible with only one type of access card.

4. Visual and audible indication that a card has been decoded and deemed valid or invalid shall be provided at each reader. Reader visual indication shall normally be red when associated door/gate/roll-up is locked/closed/down and green during the time that the door/gate/roll-up is unlocked/open/up by valid card read, remote door release, or timed unlock.

5. Automatic Door Control and Alarm Annunciation:

   a. A reader or IFP shall constantly monitor the status of its associated door via a door position switch (DPS). DPS cabling shall be supervised by the system. A door opened without proper shunting from the card reader, motion detector, exit switch or other egress device, or a cable tamper, shall immediately annunciate an alarm.

   b. A valid access card read shall shunt any associated DPS and/or horn and activate the associated control device, e.g., lock/vehicle barrier arm/roll-up gate, to permit access for an adjustable (0-99 secs.) period that shall be initially set at 10 seconds. The control device shall re-lock immediately after the door has closed.

c. Egress card readers, motion detectors, request-to-exit switches, and remote door release buttons shall shunt door contacts but shall not unlock the door where free mechanical egress is available, e.g., unlocked door handle or exit device (panic bar). They shall unlock doors where magnetic locks are used. Refer to Security Device Hardware Schedule for specific door hardware operation.

d. If the door is held open for longer than the specified period of time (initially set at 10 seconds and adjustable to 99 seconds), an alarm shall be annunciated.

e. After a "door held" condition has been detected, and the door subsequently closes, the system shall transmit a "door closed" advisory to the monitoring station.

C. Mounting

1. The height and location of the card readers is shown on security detail drawings (SEC-DET) and shall be confirmed in the field.

2. Flush mount standard readers on standard single gang back boxes, surface mount mullion readers as indicated on drawings. Mount readers per manufacturer's installation instructions with particular attention to required distances between the antennae and the reader electronics, and other metal, cabling, CRTs, and electrical/electronic components.

3. Card reader electronics boards (e.g., ARM, RM) shall be mounted in a locked Hoffman box installed above associated card reader controlled door. Box door shall be equipped with a tamper switch.

D. Reader Type and Models

1. All card reader devices shall be HID contact-less smart card readers multi-tech iCLASs.

2. For select exterior doors (as shown on Detail Drawings) provide the HID multi-iCLASS RP10 contact-less smart card reader. For all other applications provide the HID iCLASS RP40 multi technology contact-less smart card reader (no exceptions).

3. At entrances provide an HID iCLASS module and adapter as part of the door station unit (as shown on Detail Drawings.

E. Intelligent Field Panel (IFP)

1. Provide Controller and Input Modules in quantities required for specified quantities of readers and alarm/control devices.

2. The control modules for reader and door control shall be the RS2 EP-1502 two (2) card reader Controller with an additional control output and one monitoring input.

3. The input module for alarm devices (door position switches and duress buttons) shall be the MR-16IN Input modules for sixteen (16) supervised input points and two (2) output control relays.

4. Monitor each of the NCL-12 Controllers and associated module enclosure for tamper, loss of main AC power, and low battery power alarms. The enclosures shall be lockable.

5. Provide a minimum of 8-hour battery back up during loss of main power. Back-up power shall support all AC/AM functions including locks, horns, and egress sensors.

6. The RS2 Controllers and the associated modules shall operate in an off-line mode when there is a communication failure with the host system. Off-line mode shall provide full AC/AM functionality with no degradation of function, except that the IFP may not be capable of performing functions requiring data transmission to or from other IFPs or the host system. The Controller shall automatically upload all events logged since the failure, and accept a download of any database changes, when communication with the host is resolved.

7. Flash ROM for downloaded configuration programming.

8. The IFPs shall be manufactured by RS2 (no exceptions).

F. Equipment Enclosures

1. All enclosures for equipment supplied under these specifications shall be protected against tampering by being equipped with tamper switches or triggering mechanisms electrically compatible with and connected to the alarm system; or fully filled with an epoxy compound.

2. Internal wiring of device enclosures shall be such that the tamper switches and triggering mechanisms are not bypassed even though the detector itself is operating in the "ACCESS" mode.

3. All controls that affect detection sensitivity shall be located inside tamper resistant enclosure.

4. All enclosures shall be equipped with key locks with Underwriters' Laboratories listed locking cylinders. Provide Owner with 2 keys per enclosure. Similar types of enclosure, e.g., all power supply enclosures, shall be keyed alike.

5. All enclosures shall be equipped with door gaskets. All openings, e.g., for conduit, shall be sealed after installation. Enclosures shall be finished to resist the environment.

6. The enclosure for the RS2 access control system controller & processors shall be the NCL-12 no exceptions.

G. Door Position Switches (Magnetic Contacts)

1. Devices shall initiate an alarm signal whenever the switch housing is moved as much as 1 inch from the magnet housing.

2. Device housing shall be of cast non-ferrous durable material. Provide reasonable protection against moisture and dust.

3. Mechanism shall be adjustable so that the operating gap between faces of the switch housing and the magnet housing may be adjusted up to 1/2 in. to accommodate installation variances.

4. Switch shall be rated for minimum of 500,000 activations without malfunction.

5. Supply and install Sentrol, 1076 series concealed switches, or approved equal, off-white, for doors. Surface mounted switches may be substituted only after Owner approval. NO CABLE SHALL BE EXPOSED. All wire shall be concealed or in conduit.

6. All door/gate switches shall be installed with end-of-line resistors at the door/gate location.

H. Motion Sensor

1. The motion sensor shall be designed to detect motion of a human body within a protected area by means of a combination of pulsed Doppler microwave technology and passive infrared (PIR) technology. The sensor shall require both technologies to sense motion before an alarm may occur. The sensor shall be UL listed and FCC certified.

2. The PIR fields of view shall be focused on the pyroelectric sensing element by means of a plastic Fresnel lens mounted in the front cover of the housing. The PIR fields of view within the protected area shall consist of 22 long-range fields, 12 intermediate fields, 6 lower fields, and 4 lookdown fields. The lookdown fields shall be implemented by means of a mirror mounted adjacent to the pyroelectric sensing device and an infrared-transparent window mounted in the bottom surface of the sensor.

3. The microwave sensing technology shall use a center frequency between 24.125 and 24.220 GHz. An adjustment for microwave sensitivity shall be provided on the circuit board. The sensor shall incorporate a microwave supervision system, which shall activate the alarm output if the microwave technology fails.

4. The pyroelectric sensing element shall have protection against bugs and dust by means of a zero-clearance, gasketed bug guard. Sensor electronics shall be microcontroller-based. The sensor shall provide a logic-level remote LED enable input with selectable polarity.

5. The sensor shall operate over an ambient temperature range of -13 to +145 degrees Fahrenheit (-25 to +65 degrees Celsius) and shall have compensation against loss of sensitivity as the ambient temperature nears human body temperature. The sensor shall provide at least 30 V/m of RF immunity in the range 10 MHz to 1,000 MHz, and at least 8,000 lux of white light immunity.

6. The sensor housing shall be constructed of white, high-impact ABS plastic and shall be capable of wall or corner or ceiling mounting with an option for flush mounting at locations to be determined by the architect.

7. The Wall Mounted motion sensor shall be Honeywell model CK-DT-7550C series or approved equivalent.

I. Electrified Door Hardware

1. All door hardware(per Hardware Schedule) including electrified panic devices, transfer hinges, electric locks, magnetic locks, electric strikes, etc., for this project shall be supplied and installed by others. The security contractor shall be responsible for the wiring of these devices to the IFP and supplying, installing, and wiring all lock power supplies. The security contractor shall be responsible to connect to and test fire alarm interrupt relays to specified lock power supplies.

J. Door Prop Alarm (DPA)

1. Provide door prop alarms for local and remote monitoring of the secure status of the doors as indicated on the Security Device Drawings.

2. A horn within the DPA shall sound (minimum 80dB) and a normally closed alarm output contact from the DPA shall be activated whenever a monitored door is held open beyond a user adjustable time (0-60 seconds.

3. Local alarm and alarm output contact shall reset upon closure of the monitored door.

4. The DPA shall be mounted in the wall adjacent to the monitored door(s) at 42 inches A.F.F. The unit shall mount in a 2 gang electrical box with a minimum depth of 2 ½ inches.

5. Door prop alarm shall be Designed Security, Inc. Model ES411 Series.

K. Power Supplies

1. Low voltage power supplies for locks and security devices shall comply with applicable provisions of local building codes and national electrical code and shall meet requirements of all authorities having jurisdiction.

2. Power supplies shall be mounted at IT & Security Closet locations and shall be UL listed, labeled or approved. Specification section above for enclosure requirements (tamper switches and locks) is applicable for all power supply enclosures.

3. Power supplies shall be equipped with short circuit protection and overvoltage protection.

4. Lock power supplies shall be equipped with separate fuse for each lock device. For locks which require control from the building's life safety system, provide individual selectable fire alarm output power control. Fire alarm system relays shall cut selected fail safe lock power when activated.

5. Lock power supplies shall be connected to the building's emergency generator system.

6. Operating temperature of 0ºC to 55ºC.

7. Power supplies shall annunciate, via the SMS system, failure or malfunction of unit, open or short circuits, loss of main AC power, and low battery power.

8. It shall be the responsibility of the security contractor to connect the power supplies to the building’s main power system.

9. Provide Altronix Maximal Power Supplies series or equivalent.

2.6 CLOSED CIRCUIT TELEVISION SYSTEM PROVIDED BY OTHERS

2.7 SCOPE

It is the intention of these specifications (ARE FOR INFORMATION PUR POSES ONLY) to set forth the minimum requirements for the performance of an integrated CCTV System to provide highly reliable surveillance and alarm assessment. The CCTV System shall consist of:

2.8 MATERIALS CCTV

A. Identification and Tagging

1. Labels, tags or other permanent markings shall identify all cables, wires, terminal blocks and terminals.

2. All markings shall clearly indicate the function, source and destination of all cabling, wiring and terminals. All markings shall be recorded on as-built drawings.

2.9 EQUIPMENT - CCTV

A. Video Management System

The campus Video Management System (VMS) shall consist of IP cameras and network video recorders (NVR). The IP cameras shall be recorded on NVRs to be located centrally on campus. The College has standardized on the Verint (current version 6.4.2) VMS for their campus surveillance solution. The recorded or live video for viewing at the NVR workstation shall be transmitted via the campus network. The NCC IT department will provide additional NVRs and new Cisco network PoE switches as required for this project.

The color IP cameras scheduled for the building shall primarily located at the exits and pedestrian entrances of the facility as well as at the elevator lobbies and stairwell entrances to each of the building's floors. The IP cameras shall be powered via the network utilizing CAT 6 cable.

B. Fixed Interior IP Camera Domes (Color)

1. The camera shall be a network enabled mini dome color camera, utilizing a ½.8" type progressive scan RGB CMOS technology sensor. Varifocal Lens: 3.0mm – 10.5mm

2. The camera shall be manufactured with a tamper-resistant casing and metal encapsulated electronics.

3. Resolution: 1920x1080. Remote zoom & focus, WDR forensic capture

4. Video Analytics: Video motion detection, Active tampering alarm Support for AXIS Camera Application Platform enabling installation of AXIS Video Motion Detection 3, AXIS Cross Line Detection, AXIS Digital Auto tracking and third-party applications

5. Cameras shall provide the option of flush or surface mounted depending upon location. Cameras to be flush mounted wherever possible provide flush mount kits for all.

6. The camera shall be equipped with a progressive scan 1.3 megapixel sensor, support WDR and shall provide images down to 0.1 lux in day mode and 0.02 lux in night mode and 0.0 lux with IR Illuminator on in B&W

7. Zipstream technology in H.264.

8. Support simultaneous individually configured Motion JPEG and H.264 video streams.

9. Support both unicast and multicast H.264 with support for both Constant and Variable Bit Rate.

10. Support Power over Ethernet according to IEEE 802.3af.

11. Operating condition -22° F to +122° F.

12. Provide P3225-VE IP camera manufactured by Axis no exception.

C. Special 360˚ Interior IP Camera Dome

1. The camera shall be a network enabled mini dome color camera, utilizing a 1/3.2 type progressive scan RGB CMOS technology sensor. 5MP (mega-pixel) 360˚/180˚ angle of view.

2. The camera shall be manufactured with a vandal and dust resistant casing and metal encapsulated electronics.

3. Camera domes shall be equipped with a 10BASE-T/100BASE-TX Ethernet interface.

4. Cameras shall provide the option of flush or surface mounted depending upon location (refer to Camera Schedule for exact type).

5. The camera shall support several viewing modes: 360˚overview, dewarped views such as panorama, double panorama and quad views. It shall also support digital pan-tilt-zoom.

6. Provide at least two video streams at full frame rate (30 fps) in HDTV 1080p (2592x1944) resolution using H.264.

7. Support Power over Ethernet according to IEEE 802.3af

8. Provide M3007-P/-PV IP camera with clear domes manufactured by Axis or approved equivalent.

D. Outdoor IP Camera

1. The camera shall be a network enabled mini dome color camera, utilizing a ½.8" type progressive scan RGB CMOS technology sensor. Varifocal Lens: 3.0mm – 10.5mm

2. The camera shall be manufactured with a tamper-resistant casing and metal encapsulated electronics.

3. Resolution: 1920x1080. Remote zoom & focus, WDR forensic capture

4. Video Analytics: Video motion detection, Active tampering alarm Support for AXIS Camera Application Platform enabling installation of AXIS Video Motion Detection 3, AXIS Cross Line Detection, AXIS Digital Auto tracking and third-party applications

5. Cameras shall provide the option of flush or surface mounted depending upon location. Cameras to be flush mounted wherever possible provide flush mount kits for all.

6. The camera shall be equipped with a progressive scan 1.3 megapixel sensor, support WDR and shall provide images down to 0.1 lux in day mode and 0.02 lux in night mode and 0.0 lux with IR Illuminator on in B&W

7. Zipstream technology in H.264.

8. Support simultaneous individually configured Motion JPEG and H.264 video streams.

9. Support both unicast and multicast H.264 with support for both Constant and Variable Bit Rate.

10. Support Power over Ethernet according to IEEE 802.3af.

11. Operating condition -22° F to +122° F.

12. Provide P3225-LVE IP camera manufactured by Axis no exception.

E. Outdoor IP Camera Alternate

1. The alternate outdoor bullet type camera shall be a network enabled color camera, utilizing a ½.8 type PS Exmor technology imaging sensor 2.38MP, 1080P high definition,

2. The outdoor camera shall be manufactured with a vandal-resistant metal casing and metal encapsulated electronics.

3. The camera shall be IP66 and NEMA 4X-rated and operate between -40 to +55°C (-40° to +131°F), also when powered using Power over Ethernet.

4. 100dB Wide Dynamic Range, 30fps at 2 megapixel (1920x1080) resolution.

5. Min illumination, Color 0.1 lux, B/W 0.0 lux with built-in IR LEDs on

6. The camera focal length 3mm-8.5mm motorized varifocal lens

7. Support simultaneous individually configured Motion JPEG and H.264 video streams.

8. Support both unicast and multicast H.264 with support for both Constant and Variable Bit Rate.

9. Support Power over Ethernet according to IEEE 802.3af

10. The Outdoor Alternate Camera shall be manufactured by Samsung model SNO-6084R or approved equivalent.

F. 180 Degree IP Camera

The special application 180° mega pixel IP camera to be utilized to view designated interior areas which shall provide:

1. The image device shall consist of five (5) 1.3 Mpixel CMOS with 6,553,600 effective pixels
2. Electronic rolling shutter.

3. Automatic gain control.

4. Average, 5 zone independent exposure control.

5. Depth of Field is 1’ to infinity.

6. Image size (HxV) two simultaneous streams: A standard 15 fps HD frame comprised of a 1280 x 320 situational awareness (SA) window plus a 1280 x 400 sub window allocated to up to four zoom windows; And a 5120 x1280 full res stream at 1 fps.

7. The field of view shall be 180 degrees x 48 degrees; 28 pixels per degree of field view.

8. The image resolution shall be everywhere within the field of view equivalent to resolution of 1.3 MP camera with a 33.7mm lens.

9. The compression shall be H.264.

10. The maximum frame rate shall be 15fps for SA and zoom, 1 fps for full resolution window.

11. The compression ratio shall be user selectable.

12. The Bandwidth requirement using H.264 at good quality compression- HD window at 15 fps, less than 2.0 Mbit/sec.; Full Res Image at 1 fps, less than 1 Mbit/sec.

13. Network protocols: TCP/IP, HTTP, SMTP, DHCP, RTP/RTSP (Currently), DNS, BONJOUR.

14. Interface: Internet Explorer, Firefox.

15. COMM Ports Ethernet 10 Base-T/100 Base.

16. Power requirements: 48v PoE, 12v DC.

17. Camera shall be manufactured by Scallop Vision, Model D7 180 IP Camera or approved equal.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Installation shall include the delivery, storage, setting in place, fastening to the building structure, interconnection of the system components, alignment, adjustment and all other work, whether or not expressly specified which is necessary to result in a tested and operational system.

B. All installation practices shall be in accordance with, but not limited to, the specifications and drawings. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of the National Electrical Code and any authorities having jurisdiction including the "National Electrical Contractors Association National Electrical Installation Standards (NECA/NEIS).

C. During the installation and up to the date of final acceptance, the Contractor shall protect his finished and unfinished work against damage or loss. In case of such damage or loss, he shall replace or repair such work at no cost to the Owner.

D. All equipment shall be firmly secured in place unless requirements of portability dictate otherwise. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.

E. All boxes, equipment, etc., shall be plumb and square. The Contractor must take such precautions that are necessary to prevent and guard against electromagnetic and electrostatic hum, to supply adequate ventilation and to install the equipment to provide reasonable safety for the operator.

F. In the installation of equipment and cables, considerations shall be given not only to operational efficiency, but also to overall aesthetic factors.

G. Supply and install all fittings and accessories, whether or not they are specified, required for proper, safe and reliable operation of the system.

H. No exposed equipment shall be installed without approval of design, finish and mounting details.

3.2 CABLE INSTALLATION

A. System cabling shall be provided and installed under this contract.

B. All circuits shall be protected to avoid interruption of service due to short-circuiting or other conditions that might adversely affect the connected devices. Each individual signaling circuit shall be classified as a circuit pair.

C. All cabling in racks, cabinets and junction boxes shall be neatly strapped, dressed and adequately supported. Cable installation shall conform to good engineering practices and to the standards of the most current National Electrical Code. Interconnections within console and the equipment racks for all video components (NVR) shall utilize prefabricated fiber or copper Patch Chords or CAT5/6 cables with RJ45 connectors at each end.

D. All cables shall be labeled with an electronic labeler on both ends within 6" from the final termination

E. Cables shall be terminated with the proper connector required for the associated operation of the equipment to which it is connected. Screw terminal blocks shall be furnished for all cables that interface with racks, cabinets, consoles or equipment modules. Wire shall be interfaced with screw terminal blocks through the use of spade lugs installed on the cable with an installation tool specifically recommended by the manufacturer of the lug. Evidence of the installation of cables and wires without the appropriate connectors, spade lugs and tools shall be sufficient cause for rejection of the work and reinstallation of the cables or wires.

F. Where cables or wires require soldering, the soldering shall be done using rosin core solder and controlled temperature soldering equipment. Evidence of solder joints not made with rosin core solder or with non-temperature controlled tools shall be sufficient cause for rejection of the work and resoldering of all connections.

G. Every cable or wire shall be labeled or coded at each end. Each terminal of each field terminal strip shall be permanently labeled or coded to show the zone, instrument or item served. Terminal blocks shall be numbered by circuit pairs, such as 1 to 25, 26 to 50, etc.

H. All cables within a rack, console or junction box shall be grouped according to the signals being carried to reduce signal contamination. Separate groups should be formed for the following:

1. Power cables.

2. Video cables and audio cables carrying signals less than 2.0 V p-p.

H. Coaxial cables shall be run in continuous lengths. No splices shall be permitted.

I. Shielded conductors shall be installed in separate steel conduits and shall not occupy the same enclosure with unshielded conductors. Shielded conductors may be grouped together.

J. Where shielded conductors enter a panel or enclosure, and where power wiring exists, provide physical isolation of signal and power conductors. Install sleeve on shield grounds in panels. Conduit connections shall be made to assure no interaction between power and signal circuits.

K. Electrical self-stripping tap and pigtail connectors shall be tin plated brass "U" element contact. Connectors shall be 3M Brand Scotchlok 567 to 577.

3.5 GROUNDING

A. A single system ground point shall be established for the system. This shall consist of a single grounding point to which all grounds shall be connected.

B. The system ground shall be located in the base of the security equipment racks. It shall consist of copper bar sufficient in size to accommodate the required grounds.

C. The system ground is to be connected to the local ground bus by conductors, which has not more than 0.1-ohm total resistance. Under no conditions shall AC neutral either in a power panel or in receptacle outlets be used for a reference ground.

D. Contractor shall provide RF shielding and RF filtering for all systems and components to ensure no interaction with potential RF systems in proximity to the site.

3.6 FINISHES

Equipment finishes shall be manufacturer's standard unless otherwise noted in the specification. All finishes, whether standard or custom, shall be submitted for approval.

3.7 TESTING

A. When the Contractor has completed system tests to his/her satisfaction and when the system record documents, including drawings, operation and maintenance manuals, are complete, notify in writing that the system fulfills the specifications and is ready for acceptance testing.

B. Approved software packages shall be entered into the security computer systems and debugged. The contractor shall be responsible for documenting and entering the initial database into the system. The contractor shall provide the necessary blank forms with instruction to the owner to fill-in all the required data information that will

make up the database. The database shall then be reviewed by the contractor and entered into the system. A copy of the document and a copy of the recorded database on a diskette shall be made available for review on a later date. Prior to full operation, a complete demonstration of the computer real-time functions shall be performed in the presence of the Owner.

C. Upon satisfactory on-line operation of the system software, the entire installation including all subsystems shall be inspected. The Contractor shall perform all tests, furnish all test equipment and consumable supplies necessary and perform any work as required to establish performance levels for the system in accordance with the specifications. Each device shall be tested as a working component of the completed system. All system controls shall be inspected for proper operation and response. The scope of the inspection work shall include, but not be limited to, the following:

1. Document all measured values and control settings for the system. These values and settings shall be recorded in the operation and maintenance manuals and shall be made available at the time of acceptance testing, following the indicated testing procedures.

2. Check each system including all inputs and outputs for compliance with the performance standards.

3. Function of all remote sensors for proper operations and testing of all wiring. The test shall include operating each device as it should operate in normal usage. No operations are to be simulated for this test.

4. Check each control and monitoring function from all origination points to all controlled locations for proper operation.

5. Adjust each piece of equipment as required for optimum quality and to meet the manufacturer's published specifications.

6. Check to insure that all systems are free from spurious oscillation and radio frequency pickup both in the absence of any input signal and also when the system is driven to full output.

7. Establish tentative normal settings for all systems controls. All setup controls shall be adjusted for optimum system performance and shall be marked for reference.

8. Demonstrate the power-up and power-down procedure for each system. These procedures shall be documented and then incorporated into the systems operation manual.

D. All tests shall be documented by the Contractor and shall be witnessed by the Owner and the Owner's representative. Following the system test and inspection, the Owner's representative shall prepare a list of any outstanding work, which must be completed by the Contractor prior to issuance of the certificate of substantial completion.

E. Upon receipt of the Contractor's notice that all punch list items from previous inspections are complete, the Owner's representative shall re-inspect the work for final acceptance. The Contractor shall provide all test equipment, materials and personnel as required assisting in the final acceptance test. The final acceptance test shall consist of the following:

1. The Contractor shall verify that all record documentation is complete.

2. The operation of all system and equipment shall be demonstrated by the Contractor to comply with the contract documents. Both subjective and objective tests may be required by the Owner and the Owner's representative to determine compliance with the specifications.

F. Upon completion of the re-inspection, the Owner's representative shall either accept the system as being substantially complete or advise the Contractor of work not completed or obligations not fulfilled as required for final acceptance. If necessary, the entire procedure shall be repeated. Time and expenses expended by the Owner's representative for additional re-testing (beyond the initial and the first re-test) shall be back charged to the Contractor.

G. The inspections and tests may be suspended at the option of the Owner's representative if it is his opinion that major components of the system are defective. The Contractor shall have personnel available at the job site to make adjustments and repairs and take corrective action during the tests.

H. The system shall be accepted as complete when all work has been completed; all remedial work is performed; all documentation is complete, accurate and accepted; and the Owner's personnel has received the specified training.

I. Complete logs of tests shall be retained by the Contractor for inspection and review at any time after the testing has started. Upon final completion of system tests the log records shall be submitted.

J. Submit detailed test checklist and descriptive methodology for approval at least 4 weeks prior to start of test.

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SECTION INCLUDES

A. Fire-alarm control unit.

B. Fire alarm control unit with digital voice evacuation.

C. Manual fire-alarm boxes.

D. System smoke detectors.

E. Heat detectors.

F. Notification appliances.

G. Firefighters' two-way telephone communication service.

H. Magnetic door holders.

I. Remote annunciator.

J. Addressable interface device.

K. Digital alarm communicator transmitter.

L. System printer.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

A. Non-coded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 SUBMITTALS

A. Submit under provisions of Section 01 33 00.

B. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop drawings shall be prepared by persons with the following qualifications:

1. Trained and certified by manufacturer in fire-alarm system design.
2. NICET-certified fire-alarm technician, Level III minimum.
3. Licensed or certified by authorities having jurisdiction.

C. Product Data: For each type of product indicated.

D. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" section of the "Fundamentals of Fire Alarm Systems" chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm

indicators. Locate detectors according to manufacturer's written recommendations.

6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

E. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

F. Qualification Data: For qualified installer.

G. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

H. Field quality-control reports.

I. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, include the following:

1. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" section of the "Inspection, Testing and Maintenance" chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    1. Frequency of testing of installed components.
    2. Frequency of inspection of installed components.
    3. Requirements and recommendations related to results of maintenance.

4. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

J. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.

C. Upgrade Service: Update software to latest version at project completion. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one (1) unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one (1) unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one (1) unit of each type.
4. Detector Bases: Quantity equal to two (2) percent of amount of each type installed, but no fewer than one (1) unit of each type.
5. Keys and Tools: One (1) extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One (1) of each type installed.
7. Fuses: Two (2) of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. Federal Signal Corporation.
2. Fire Control Instruments, Inc.; a Honeywell company.
3. Fire Lite Alarms; a Honeywell company.
4. GE Infrastructure; a unit of General Electric Company.
5. NOTIFIER; a Honeywell company.
6. Siemens Building Technologies, Inc.; Fire Safety Division.
7. Silent Knight; a Honeywell company.
8. SimplexGrinnell LP; a Tyco International company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one (1) or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Verified automatic alarm operation of smoke detectors.
6. Automatic sprinkler system water flow.

7. Heat detectors in elevator shaft and pit.
8. Fire-extinguishing system operation.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Activate emergency lighting control.
11. Activate emergency shutoffs for gas and fuel supplies.
12. Record events in the system memory.
13. Record events by the system printer.

C. Supervisory signal initiation shall be by one (1) or more of the following devices and actions:

1. Valve supervisory switch.
2. Elevator shunt-trip supervision.

D. Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

E. System trouble signal initiation shall be by one (1) or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Carbon monoxide device activation.
10. Integral smoke detector installed on a smoke damper and/or fire smoke damper.

F. Trouble Signal Actions: Annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.

    1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
    2. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 2 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.

    1. Initiating Device Circuits: Style E.
    2. Notification Appliance Circuits: Style Z.
    3. Signaling Line Circuits: Style 7.
    4. Install no more than 50 addressable devices on each signaling line circuit.

2. Serial Interfaces: Two (2) RS-232 ports for printers.

D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

E. Notification Appliance Circuit: Operation shall sound in a pattern.

F. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.

    1. Elevator lobby detectors except the lobby detector on the designated floor.
    2. Smoke detector in elevator machine room.
    3. Smoke detectors in elevator hoistway.

2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

    1. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.

1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.

    1. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
    2. Programmable tone and message sequence selection.
    3. Standard digitally recorded messages for "Evacuation" and "All Clear."
    4. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

J. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch. The secondary power supply for emergency voice/alarm communications shall have sufficient capacity to operate the fire alarm system under quiescent load (system operating in a non alarm condition) for a minimum of 24 hours and at the end of the period shall be capable of operating the system during an emergency condition for a period of 15 minutes at maximum connected load. The secondary power supply shall automatically provide power to the fire alarm system within 10 seconds whenever the primary power supply fails to provide the minimum voltage required for power operation.

1. Batteries: Sealed lead calcium.

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 FIRE-ALARM CONTROL UNIT WITH DIGITAL VOICE EVACUATION

A. The system shall be complete, electrically supervised fire detection and evacuation system using one way communication and Firefighters telephone and smoke control systems with microprocessor based operating system having the following capabilities, features and capacities:

1. Voice amplification shall be supervised and backed up with like amplifiers. Back up shall be one for one. Backup amplifiers shall not share components and must be fully stand-alone.

2. Amplifiers shall be rated for 25V or 70.7V RMS, 40 watts.

3. Amplifiers shall be rated for 25V or 70.7V RMS, 180 watts.

4. Amplifiers shall be sized as minimum, to accommodate speakers in corridors at 2 watts and other locations 1 watt.

5. The system shall have the capability to support Peer-to-Peer or Master-Slave network and voice configurations.

6. Multiple nodes shall provide peer-to-peer voice capability in order to eliminate a single point of failure.

7. Audio shall be synchronized between nodes in order to take into account common areas.

8. The network, audio, and telephone risers between nodes shall be copper and support Class A loop configuration to allow communication to continue in the event of a fault.

9. Speakers shall have the ability to play coded audio tones.

10. Voice evacuation system amplifiers shall be configured as distributed, bulk, or a combination of distributed and bulk audio. If necessary, convenience paging and/or background music shall be available via UL-listed speakers.

B. Additional system operation for Fire Alarm Condition for Voice:

1. Sound an pre-announce tone followed by a field programmable digitized custom evacuation message, on the floor of alarm, the floor below and the floor above. The visual signals shall operate in a similar pattern.

2. A simultaneous message shall be delivered via all alarm speakers installed on the remaining floors indicating the requirement for occupants of these floors to remain alert for further instructions.

3. A simultaneous message shall be delivered via all alarm speakers installed in stairways and elevators informing occupants of the imminent shutdown of elevator circuits and the expected high traffic load in the stairwells.

4. An automatic announcement or tone evacuation signal shall be capable of interruption by the operation of the system microphone to give voice evacuation instructions overriding the pre-programmed sequences.

5. Status lights next to speaker selection switches on the control panel shall indicate speaker circuit selection.

6. Audible signals shall be silenced from the fire alarm control panel by an alarm silence switch. Visual signals shall be programmed to flash until system reset or alarm silencing, as required by the AHJ.

2.5 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Double-action mechanism requiring two (2) actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.
   3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
   4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be four-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors:

   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

      1. Primary status.

2. Device type.

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.7 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 degree F or a rate of rise that exceeds 15 degree F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 degree F.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

C. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

D. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

E. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output:
    1. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, [red] [white].

F. Voice/Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Low-Range Units: Rated 1 to 2 W.
4. Mounting: Flush.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.9 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit, the fire command center, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:

1. Common-talk type for firefighter use only.
2. Selective-talk type for use by firefighters and fire wardens.
3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
4. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.
5. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
6. Display: Liquid-crystal digital to indicate location of caller.
7. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
    1. Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Warden Phone" or "Fire Emergency Phone."
    2. With "break-glass" type door access lock.
8. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Warden Phone" or "Fire Emergency Phone."
9. Handsets: push-to-talk-type sets with noise-canceling microphone stored in a cabinet adjacent to fire-alarm control unit.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall, to circuit-breaker shunt trip for power shutdown, etc.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two (2) telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 SYSTEM PRINTER

A. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches above the finished floor. Comply with requirements for concrete base specified in Section 03 30 00.

1. Install seismic bracing. Comply with requirements in Section 26 05 48.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 26 05 48.

D. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
5. HVAC: Locate detectors not closer than three (3) feet from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

E. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

F. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

G. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

K. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

L. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 08 71 00. Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than three (3) feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated air-conditioning duct systems.
2. Alarm-initiating connection to elevator recall system and components.
3. Alarm-initiating connection to activate emergency lighting control.
4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at elevator shunt trip breaker.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 48.

B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    1. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals of Fire Alarm Systems" chapter.
    2. Comply with "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals of Fire Alarm Systems" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One (1) year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative in a 4-4 hour sessions to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: cutting trees, shrubs, and bushes; removing stumps; removing other materials; disposal of materials; stripping and stockpiling topsoil.

PART 2 – PRODUCTS

A. None required by this Section.

PART 3 – EXECUTION

3.01 CLEARING AND GRUBBING

A. Remove all rubbish and debris from within the Contract limits.

B. Remove trees, saplings, shrubs, bushes, vines, undergrowth, stumps, and roots from areas to be occupied by buildings, structures, roadways, parking lots, pipelines, and lawns.

C. The Owner will designate trees and other plants to remain. Protect those trees and plants from damage by erecting barricades, fences, or by other acceptable means. Prevent falling trees from damaging trees and plants designated to remain.

D. Protect areas outside the limits of clearing from damage by the clearing and grubbing operations.

E. Grubbing operations are prohibited within the wetland limits. Wetland disturbance is strictly prohibited. Clearing shall be conducted in such a manner to not disturb the wetland area. All stumps shall remain in wetland areas.

3.02 STRIPPING AND STOCKPILING TOPSOIL

A. Strip topsoil from cleared areas. Do not mix topsoil with subsoil. Keep topsoil free of brush, trash, large stones, and other extraneous material.

B. Stockpile topsoil at areas on the site as directed by the Architect. Protect the stockpiles of topsoil until used for lawns and other plantings under other Sections of these Specifications.

C. Any topsoil remaining after all work is in place shall become the property of the Contractor. The Contractor shall dispose of the topsoil off the site.

D. The Contractor shall supply additional topsoil at his expense if there is a shortage from stripping.

3.03 DISPOSAL OF MATERIAL

A. No burning will be allowed.

B. All rubbish, debris, logs, stumps, roots, cuttings, and other materials resulting from the clearing and grubbing operations shall become the property of the Contractor and shall be disposed of by him off the site. The manner of disposal shall comply with all applicable local, state, and federal regulations.

END OF SECTION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Excavate trenches for utilities; compacted bedding under and compacted fill over utilities to subgrade elevations; backfilling and compaction. Work under this item also include the complete replacement of all items disturbed by trenching activities, including sidewalks, curbs, signs, pavement, etc.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

B. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction, Form 816 (2004), as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

1.03 REGULATORY REQUIREMENTS

A. Notify utility companies in accordance with Public Act 77-350 'CALL BEFORE YOU DIG", (1-800-922-4455).

B. Comply with United States Department of Labor, Occupational Safety and Health Administration.

C. Construction Standards for Excavations, 29 CFR part 1926, subpart P.

D. Obtain required permits from authorities.

E. Do not close or obstruct roadways, sidewalks, or hydrants without permits.

F. Comply with all applicable requirements of State and local authorities for trenching, backfilling and maintenance and protection of traffic within city streets.

1.04 SUBMITTALS

A. Samples of filter cloth and warning tape shall be submitted for approval. Other samples and certificates of compliance may be requested.

B. Where sheeting and shoring is used, complete sheeting and shoring sketches and calculations shall be prepared by a Connecticut registered Professional Engineer and shall meet OSHA regulations.

PART 2 – PRODUCTS

2.01 CRUSHED STONE

A. Crushed stone of the size specified shall conform to the requirements of Section M.01.01 of the DOT specifications.

2.02 SAND

A. Conform to Section M.03.01-2 of the DOT Specifications.

2.03 GRANULAR FILL

A. Conform to Section M.02.01 of the DOT Specifications.

2.04 BACKFILL MATERIAL

A. Wherever reference is made on the Drawings or in the Specifications to suitable material, suitable backfill material, and suitable fill material, the material shall be mineral soil substantially free from organic materials, topsoil, wood, trash, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall not contain rocks or lumps larger than six (6) inches in largest dimension, and not more than 15 percent of the rocks or lumps shall be larger than 2 1/2 inches in largest dimension. Further, it shall not contain granite blocks, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted during filling. Snow, ice, and frozen soil will not be permitted.

2.05 GEOTEXTILE FILTER CLOTH

A. Geotextile filter cloth shall conform to the requirements of Section M.08.01-26 of the D.O.T. Specifications. Geotextile shall be approved for subsurface drainage use, Class A.

2.06 WARNING TAPE

A. Warning tape shall be 3-inch wide, detectable, color to suit utility being identified.

2.07 SHEETING AND SHORING

A. Lumber used for sheeting, rangers, bracing, and other construction purposed shall be sound, straight grained, free from shakes, loose knots and other defects liable to impair its strength or durability. Lumber and sheeting may be reused if not ordered left in place and if in good condition. Lumber shall be spruce and/or fir.

PART 3 – EXECUTION

3.01 GENERAL

A. Verify that backfill materials to be used are acceptable.

3.02 PREPARATION

A. Identify required lines, grades, levels, contours, and datum.

B. Maintain and protect existing above and below grade utilities to remain. The contractor shall contact “Call Before You Dig” utility locating service at 1-800-922-4455 at least 48 hours prior to the start of any site construction to have existing underground utilities located.

C. Protect trees, plant life, lawns, rock outcropping, and other features remaining as a portion of final landscaping.

D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

E. Cut out soft areas of subgrade not capable of insitu compaction. Backfill with granular fill and compact to density equal to or greater than requirements for subsequent backfill material.

3.03 EXCAVATION

A. Excavate subsoil required for utility installation.

B. Excavate rock and unsuitable material as specified in Section 02 21 00 – Earthwork.

C. Make all trenches open vertical construction with sufficient width to provide free working space at both sides of the trench and around the installed item as required for caulking, jointing, backfilling, and compacting.

1. Depth: Excavate to the elevations shown on the Drawings.

2. Excavation shall not interfere with normal 45 degree bearing splay of foundations.

3. Hand trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.

4. Remove lumped subsoil and boulders.

D. Correct unauthorized excavation.

E. Correct areas over-excavated by error. Where trench excavation is inadvertently carried below proper elevations, fill with granular fill and compact to provide a firm and unyielding subgrade or foundation at no additional cost to the Owner.

F. Stockpile excavated material in area designated on site and remove excess material not being used, from site.

G. Keep excavations dry; Construction work to be installed "in the dry". Do not use pipe being constructed for trench drainage.

H. Grade top perimeter of excavation to prevent surface water from draining into trench. Do not obstruct surface drainage, but provide means whereby storm water is diverted into existing gutters, other surface drains, or temporary drains.

3.04 SHEETING AND SHORING

A. Trench Bracing:

1. Properly support all trenches in strict accordance with all pertinent rules and regulations.

2. Brace, sheet, and support trench walls in such a manner that they will be safe and that the ground alongside the excavation will not slide or settle, and that all existing improvements of every kind, whether on public or private property, will be fully protected from damage.

3. In the event of damage to such improvements, immediately make all repairs and replacements necessary at no additional cost to the Owner.

B. The Contractor shall leave in place all sheeting and bracing which the Engineer may direct him in writing to leave in place at any time during the progress of the work for the purpose of preventing injury to structures, utilities, or property, whether public or private. All sheeting to be left in place shall be cut off at least 3' below paved surfaces and 2' below non-paved surfaces.

C. All sheeting and bracing not left in place shall be carefully removed in such manner as not to endanger the construction of other structures, utilities, or property. All voids left or caused by withdrawal of sheeting shall be immediately refilled with sand by ramming with tools especially adapted to that purpose.

D. Sheeting and bracing ordered to be left in place shall not be construed as creating any obligation on his part to issue such order, and his failure to exercise his right to do so shall not relieve the Contractor from liability for damages to persons or property occurring from or upon the work occasioned by negligence or otherwise growing out of a failure on the part of the Contractor to install or leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

3.05 PIPE AND STRUCTURE BEDDING

A. Grade trench bottoms for pipes, manholes, catch basins, utility services, and other items to provide a smooth, firm, and stable foundation free from rock points.

B. Support pipe conduit during placement and compaction of bedding fill. Provide continuous bedding layer. Use of blocking not acceptable.

C. Pipes and structures shall be bedded and backfilled as detailed in the drawings.

3.06 PIPE BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen materials.

B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces.

C. Backfill in accordance with trench details.

D. Place and compact backfill materials in continuous layers not exceeding 8 inches compacted depth, compacted as shown on the drawings.

E. Employ placement and compaction methods that do not disturb or damage pipes, conduits or structures.

F. Maintain optimum moisture content of backfill materials to attain required compaction density.

G. Remove surplus backfill materials from site.

H. Leave fill material stockpile areas completely free of excess fill materials.

3.07 TOLERANCES

A. Top Surface of Backfilling: Plus or minus one inch from required elevations.

END OF SECTION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Controlling sedimentation and erosion as shown on the Drawings and as specified.

1.02 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges, and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 HAY BALES AND STAKES

A. Hay Bales: Forty pounds minimum weight and 120 pounds maximum weight.

B. Wood Stakes:

1. Two (2) per bale for securing bales.

2. Sizes: As shown on the Drawings.

2.02 MATERIALS FOR SILT FENCE

A. Filter Fabric; Filter Cloth:

1. Subarticle M.08.01-26, DOT Specifications.

2. Obtain manufacturer's certification that filter fabric conforms to the requirements of these Specifications.

3. Obtain the filter fabric from a manufacturer who produces the material for use in silt fences and who has a design for that use.

4. Do not use fabric susceptible to deterioration in sunlight.

5. Submit 2-foot square sample and technical data sheet for acceptance by the Owner.

6. Submit manufacturer's installation instructions for acceptance by the Owner.

B. Posts or Other Suitable Mounting:

1. Lengths of wood posts: As shown on the Drawings. Cross-section dimensions: As recommended by filter fabric manufacturer.

2. Other Suitable Mounting: As recommended by the manufacturer.

C. Provide materials as required by the manufacturer for attaching fabric to posts.

2.03 MATERIALS FOR ANTI-TRACKING PAD

A. Crushed Stone: Sound, tough and durable; free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. Grading: Article M.01.01, DOT Specifications No. 4.

B. Filter Cloth: Subarticle M.08.01-26, DOT Specifications.

2.04 EROSION-CONTROL BLANKETS

A. Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 – EXECUTION

3.01 PLACING HAY BALES

A. Place hay bales at slopes, at catch basins and at other locations as shown on the Drawings.

B. Embed hay bales to a depth of 6 inches.

C. Drive stakes through hay bales into ground to secure hay bales.

D. Place and stake hay bales at all locations as necessary to intercept and to filter overland stormwater flows before these flows enter streams or ponds.

E. Whenever pumping water from excavations, discharge the water such that it passes through hay bales before entering a storm drain or water body.

F. Remove accumulated sediment and replace bales when system becomes clogged or when directed by the Owner.

G. Remove hay bales at completion of project unless the Owner directs otherwise.

3.02 CONSTRUCTION AND MAINTENANCE OF SILT FENCES

A. Construct silt fences as shown on the Drawings.

B. Construct silt fences in accordance with manufacturer's instructions as accepted by the Owner.

C. Maintain or replace silt fences until they are no longer necessary or as ordered by the Owner.

D. Remove silt fences at completion of project unless the Owner directs otherwise.

3.03 CONSTRUCTION AND MAINTENANCE OF ANTI-TRACKING PAD

A. Construct anti-tracking pad at location shown on the Drawings.

B. Excavate to length, width and depth dimensions as shown on the Drawings.

C. Place filter cloth on excavated subgrade.

D. Place crushed stone on filter cloth to depth as shown on the Drawings.

E. Maintain the entrance in a condition that will prevent tracking or flowing of sediment onto the public right-of-way. When necessary, increase thickness by adding additional crushed stone; or increase length by excavating to subgrade and placing additional filter cloth and crushed stone; or do both in order to prevent tracking or flowing of sediment. Immediately remove all sediment spilled, dropped, washed or tracked onto the public right-of-way.

F. Remove anti-tracking pad at completion of project unless the Architect directs otherwise or at a time when permanent access can be constructed.

3.04 CONSTRUCTION OF EROSION CONTROL BLANKETS

A. Protect seeded areas with slopes exceeding 1V:3H or as indicated on the plans with erosion-control blankets installed and stapled according to manufacturer's written instructions.

3.05 COMPLIANCE WITH GUIDELINES AND PERMITS

A. The Contractor shall review the CTDEP guidelines (Connecticut Guidelines for Soil Erosion and Sediment Control), and the requirements of the General Permit for the

Discharge of Stormwater and Dewatering Wastewaters Associated with Construction Activities prior to any site disturbance.

B. Inspection shall be performed in accordance with the General Permit as directly cited below:

1. "Qualified personnel (provided by the permittee) shall inspect disturbed areas of the construction activity that have not been finally stabilized, structural control measures, and locations where vehicles enter or exit the site at least once every seven calendar days and within 24 hours of the end of a storm that is 0.1 inches or greater. Where sites have been temporarily or finally stabilized, such inspection shall be conducted at least once every month for three months."

2. "Disturbed areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures shall be observed to ensure that they are operating correctly. Where discharge locations or points are assessable, they shall be inspected to ascertain whether erosion control measures are effective in preventing significant impacts to receiving waters. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site sediment tracking."

3. "Based on the results of the inspection, the description of the potential sources and pollution prevention measures identified in the Plan shall be revised as appropriate as soon as practicable after such inspection. Such modification shall provide for timely implementation of any changes to the site within 24 hours and implementation of any changes to the Plan within three calendar days following the inspection. The plan shall be revised and the site controls updated in accordance with the General Permit."

C. Stormwater runoff shall be directed away from disturbed areas whenever possible by the use of temporary berms, swales hay bales or silt fence.

D. In areas where more than 2 acres will be disturbed, sediment traps or other controls will be constructed in accordance with the guidelines.

E. For discharge points that serve an area with more than 5 disturbed acres at one time, a sediment basin, designed in accordance with the guidelines, shall be installed and shall provide a minimum of 134 cubic yards of water storage per acre drained. The sediment basin shall be maintained until final stabilization of the contributing area. This requirement shall not apply to flows from off-site areas and flows from the site that are either undisturbed or have undergone final stabilization where such flows are diverted around the sediment basin. Outlet structures from sedimentation basins shall not encroach upon a wetland.

F. The Owner or its representative may require additional controls, as they are deemed necessary due to construction phasing, weather conditions, or other unforeseen conditions that cause excessive soil erosion or sedimentation.

END OF SECTION

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PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included: Bituminous concrete drives, parking, and patching, complete in place, as shown on the Drawings and as specified herein including:

1. Saw cut existing pavement as required.

2. Painted pavement markings and legends.

3. Maintenance and protection of pedestrian traffic as required.

1.02 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Subbase crusher-run stone conforming to the requirements of Article M.01.01, for No. 6 stone (3/8" crushed stone), DOT Specifications or to the following:

Sieve Size	Percent Passing
3.5"	100
¾"	50-100
No. 4	25-75

The fraction, passing the No.4 sieve shall have less than 15% passing the No. 200 sieve.

B. Base: Processed aggregate for the base shall conform to the requirements of Article M.02.03, Grading "C" of DOT Specifications.

C. Pavement Materials:

1. Bituminous concrete mixtures conforming to the requirements of Section M.04 of the DOT Specifications.

2. In Section M.04, reference is made to the Chief, Materials Testing Section, to the Materials Testing Section, and to the Laboratory; none will be involved in this work. Do the work of the Chief, the Section, and the Laboratory; or arrange for the producer of the bituminous concrete to do this work. Make the determinations, verifications, rejections, approvals, tests, and inspections as specified by Section M.04 and as necessary to produce satisfactory bituminous mixtures.

D. Tack Coat: Section M.04 of the DOT Specifications.

E. Joint Sealer: A rubber compound of the hot-poured type conforming to the requirements of Article M.04.02 of the DOT Specifications.

F. Paint: Shall conform to Section M.07.21 of the DOT Specifications for Hot Applied Pavement Marking Paint.

PART 3 – EXECUTION

3.01 INSPECTION

A. Examine the areas and conditions under which work of this Section will be installed. Correct conditions detrimental to proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 FINAL PREPARATION OF SUBGRADE

A. After preparation of subgrade as specified in Section 31 20 00 – Earth Moving of these Specifications, thoroughly scarify and sprinkle the entire area to be paved, and then compact by rolling to a smooth, hard, even surface of 95 percent of modified optimum density to receive subbase. Finish to the required grades, with due allowance for the thickness of bituminous concrete courses to be placed thereon.

B. Equipment: Compact by rolling with a 15-Ton vibratory roller.

3.03 CONSTRUCTION OF SUBBASE AND BASE COURSE

A. After subgrade has been completed and accepted by the Architect, construct the subbase and base over all areas to be paved.

B. Construct subbase in accordance with the requirements of Article 2.12.03 of the DOT Specifications, however compact with four passes of a 15-Ton (static weight) roller.

C. Construct base in accordance with the applicable requirements of Article 3.04.03 of the DOT Specifications. Compact to at least 98 percent of modified optimum density.

3.04 CONSTRUCTION OF BITUMINOUS CONCRETE PAVEMENT

A. Construct pavement in courses as called for on the Drawings. Use a class of bituminous concrete for each course as indicated on the Drawings. Thickness of each course: As shown on the Drawings.

B. Construct the bituminous concrete pavement in accordance with Article 4.06.03 of the DOT Specifications, except as modified below:

1. Article 4.06.03-1 Samples: Samples will not be taken by Materials Testing Section. Arrange for the producing plant to take its own samples to ascertain that mixtures are proper. Provide certifications. The Contractor will have the ultimate responsibility.

2. Article 4.06.03-2 Mixing Plant Inspection:

a. Inspections, verifications, determinations, and approvals at the mixing plants will not be made by the Chief, Materials Testing Section. The Contractor will be responsible for mixtures and shall take whatever steps are required to ensure production of satisfactory mixtures. He shall certify that mixtures do meet specifications.

b. Weights of completed mixtures will not be required.

3. Article 4.06.03-3 Mixing Plant Inspection - Field Laboratory: Delete in its entirety.

4. Article 4.06.03-4: Delete "Assistant Manager of Materials Testing" and substitute "Contractor."

5. Article 4.06.03-5: Delete "Assistant Manager of Materials Testing" wherever it appears and substitute "Contractor."

C. Certifications: Furnish certified test reports, material certificates, and certificates of compliance in accordance with the requirements of Article 1.06.07 of the DOT Specifications.

3.05 APPLICATION OF PAINTED PAVEMENT MARKINGS AND LEGENDS

A. The contractor shall furnish a technical advisor, who shall be fully knowledgeable of all equipment operations and application techniques, to oversee the project operation.

B. Pavement markings shall be applied in accordance with the details shown on the Drawings, in accordance with Section 12.09 of the DOT Specifications and as directed by the Architect.

C. The road surface shall be cleaned to the satisfaction of the Architect just prior to application. Pavement cleaning shall consist of at least brushing with a rotary broom (non-metallic), and additionally as recommended by the material manufacturer and acceptable to the Architect.

D. The painted pavement markings application shall immediately follow the pavement cleaning. Operations shall be conducted only when the pavement surface temperatures are 50°F or greater.

E. After application the paint shall be protected from crossing vehicles and pedestrians for a time at least equivalent to the drying time of the paint.

F. The contractor shall place necessary “spotting” at appropriate points to provide horizontal control for striping and to determine necessary starting and cutoff points. Longitudinal joints, pavement edge and existing markings shall serve as horizontal control when so directed.

3.06 PROTECTION

A. Protect from traffic during all operations.

3.07 FINISH TOLERANCES

A. Finish surfaces to the following tolerances.

1. Subbase and Base: Plus 0.00 feet to minus 0.10 feet from line and grade shown on the Drawings.

2. Bituminous Concrete Surface Course: Plus or minus 0.05 feet at any point from line and grade shown on the Drawings. No variations in surface more than 1/8 inch in a 10-foot plane.

END OF SECTION

PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Portland cement concrete sidewalks, utility pads and dumpster pads, complete in place, as shown on the Drawings and as specified.

1.02 APPLICABLE SPECIFICATIONS

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Concrete: Article M.03.01, DOT Specifications. Class 'F', 4500 psi.

B. Air-Entraining Portland Cement and Air-Entraining Admixture: Article M.03.01, DOT Specifications.

C. Reinforcement:
1. Welded Wire Mesh: WWM shall be used in all concrete sidewalk ramps and concrete sidewalk locations. The WWM shall be W1.4xW1.4 and conform to the latest AASHTO M55M/M55-94 "Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement."

2. Written request may be made to substitute synthetic:
100% virgin polypropylene fibers, minimum 1.5lbs per cubic yard or as approved by the manufacturer. Acceptable manufacturers of polypropylene fibers are W.R. Grace, Fibermesh, and Forta Corp.

D. Granular for Base: Article M.02.01, DOT Specifications.

E. Expansion Joint Filler: For installation at expansion joints: Bituminous cellular type, AASHTO M213.

F. Salt Guard: Per Connecticut DOT Qualified Product List.

G. Dowels: AASHTO M31-92, Grade 60. All smooth metal dowels shall be 5/8" diameter and 18" in length.

PART 3 – EXECUTION

3.01 INSPECTION

A. Examine the areas and conditions under which work of this Section will be installed. Correct conditions detrimental to proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 CONSTRUCTION METHODS

A. Conform to the requirements of Article 9.21.03 of the DOT Specifications.

B. Install expansion joint filler at expansion joints located as shown on the Drawings

END OF SECTION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Work Included: Granite curbing, complete in place, as shown on the Drawings and as specified herein.

1.02 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816(2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Gravel Base Material: Article M.02.01, DOT Specifications.

B. Concrete: Article M.03.01, DOT Specifications. Class 'C', 3300 psi.

C. Precast Concrete Curb: Shall consist of concrete with a minimum 28 day compressive strength of 4,000 psi containing 5 to 7% entrained air, free of cracks, honeycombs, deformities or imperfections.

D. Extruded Concrete Curb (When indicated on the Contract Drawings):.Shall be designed to include approximately 75 percent State of Connecticut approved concrete sand and 25 percent 3/8" crushed stone. The concrete shall contain a minimum of one pound of fiber reinforcement per cubic yard. The concrete shall contain a minimum of 620 pounds (6.5 sacks) of cement per cubic yard yielding a concrete that will exceed 4,000 P.S.I. in 28 days. The concrete shall be produced according to ASTM C 94 Ready Mixed Concrete or ASTM C 685 Concrete Produced by Volumetric Continuous Mixing.

E. Preformed Expansion Joint: Shall comply with the provisions of ASTM D1751 (AASHTO M213).

PART 3 - EXECUTION

3.01 EXCAVATION (CAST-IN-PLACE CURB)

A. Excavation, including removal of any existing curbing or driveway shall be made to the required depths below the finished grade, as shown on the Contract

Drawings or as directed. All soft and yielding material shall be removed and replaced with suitable material. Compact the subgrade to a firm even surface.

3.02 PAVEMENT SECTION GRAVEL SUBBASE MATERIAL (CAST-IN-PLACE CURB)

A. Pavement Section Gravel Subbase Material used for curb foundation shall be in accordance with Section 02 21 00 – Earthwork, 2.1.B, placed to the dimensions shown on the Contract Drawings and be properly compacted. The base shall be wetted and compacted prior to placing of concrete.

3.03 PREPARATION

A. Proofroll prepared base material surface in accordance with Section 02 21 00 – Earthwork – Earthwork to check for unstable areas. Paving work shall begin only after unsuitable areas have been corrected and are ready to receive paving.

B. Remove loose material from compacted base material surface to produce firm, smooth surface immediately before placing concrete.

3.04 PLACING OF CONCRETE (CAST-IN-PLACE)

A. Concrete shall contain not less than five nor more than seven percent entrained air at the time the concrete is deposited within the forms. Concrete shall be placed only on a moist base. Concrete shall not be placed on a soft, muddy or frozen base.

Precast concrete curbing may be used if approved by the Engineer and if the resulting product conforms with the plans except for the length of each curb unit. Precast concrete curbing units may be constructed in six foot or longer lengths for straight sections

Where precast concrete curbing is not used, the concrete shall be placed in forms, struck off with a template, compacted by approved means, and finished to a smooth, even surface. Vibration will not be required.

3.05 FORMS (CAST-IN-PLACE CURB)

A. Forms shall be of metal or wood, straight, free from warp and of sufficient strength to resist spring from the pressure of the concrete. Wood shall be of 2 inch surfaced plank, except that at sharp curves thinner material may be used provided sufficient bracing is maintained. Metal shall be of approved section and shall have a flat surface on the top. Forms shall be securely staked, braced, and held firmly to the required line and grade and shall be sufficiently tight to prevent leakage of concrete. All forms shall be cleaned and oiled or wetted before concrete is placed against them.

Forms shall be so constructed that the form for exposed faces may be removed before the concrete has taken final set in order to permit correction of surface irregularities.

3.06 FINISHING (CAST-IN-PLACE CURB)

A. Finishing for any portion of the surface of face of the curb departing more than one-fourth (1/4) of an inch from a straight edge ten (10) feet in length placed on the line of the curb, or should any part of the exposed surface present a wavy appearance, the same will be sufficient cause for rejection of that portion of the work. Exposed surfaces of curbing shall have a rubbed finish.

3.07 JOINTS (CAST-IN-PLACE CURB)

A. Joints for all concrete curb shall be jointed or flagged in sections approximately every ten (10) but not less than six (6) feet in length. Where walks and curbs are combined, jointing or flagging shall be at the spacing and locations as specified for walks.

3.08 EXPANSION JOINTS (CAST-IN-PLACE CURB)

A. Expansion Joints consisting of one-half (1/2) inch joint shall be provided at not more than twenty (20) feet intervals, which shall be filled up to one-half (1/2) inch below the surface of the curb with preformed bituminous joint filler. All construction and expansion jointing shall extend to the bottom of the concrete. A similar joint shall be provided at each intersection of sidewalk and street curb. Where walks and curbs are combined, expansion joints shall be placed at the same spacing and location as specified for walks.

3.09 CURING AND PROTECTION (CAST-IN-PLACE)

A. Curing and Protection for concrete curbing, shall be in conformity with the following requirements as approved by the Engineer:

1. Moist Curing: Immediately after finishing, the concrete surface shall be protected by careful covering with moist cotton mats. The mats shall be kept saturated for a period of seven (7) days.

2. Cover Sheet Curing: As soon as practicable after finishing the concrete surface, waterproof paper or white polyethylene sheeting shall be carefully placed so that adjoining sheets shall overlap at least 12 inches, and the lap shall be securely weighted down to form a closed joint. Upon removal of the forms, the exposed edges shall be completely covered. Cover sheets shall remain in place for a period of seven (7) days. Reused cover sheets shall be in good condition in the opinion of the Engineer. If hairline cracking develops before the cover sheets can be

placed, moist curing mats shall be used for the initial 24-hours of the curing period, and cover sheets placed for the remaining six (6) days.

Where moisture retaining covers are used, care shall be taken to cover the entire concrete surface including exposed sides of members. The covers shall be kept constantly moist and have sufficient strength to withstand wind and abrasive action. Covers shall be placed as soon as possible after free surface water has disappeared and the surface is hard enough to resist marring from the covers. Covers shall remain in place for seven (7) days.

3. Liquid Membrane-Forming Compound: Compound shall be applied immediately following the disappearance of water seen following final finishing and before any marked dehydration of the concrete or surface checking occurs. The compound shall be applied by an approved pressure sprayer provided with an agitator device to prevent settlement.

   The compound shall be applied in a continuous, uniform film at not less than one gallon per 200 square feet.

   If the forms are removed before the seven (7) days curing period, the exposed sides shall be pointed, cleaned and covered with the compound.

   Treated areas that become damaged by rain or wear shall be retreated to the original requirements.

4. Cold Weather Protection when, in the opinion of the Engineer, the condition of the weather is such that any concrete which has not been completely cured is liable to be frozen, such concrete shall be protected by covering it, as soon as the concrete has hardened sufficiently, with the curing material of the quality specified above, upon which shall be placed a layer of hay or straw, 6 to 8 inches in thickness, over which another layer of mats or cover sheets shall be spread.

   The edges of these covers shall be firmly fastened in place. The protection material shall remain in place for such time as the Engineer may direct. Any concrete placed during foul or cold weather is done at the Contractor's risk, and all damaged sections shall be removed and replaced at his own expense.

3.10 REMOVING FORMS (CAST-IN-PLACE)

A. Removing Forms shall not commence from freshly placed concrete until concrete has set for at least 12-hours.

3.11 BACKFILLING (CAST-IN-PLACE CURB)

A. Backfilling shall be performed after the concrete has set sufficiently. The grading shall be completed to the lines shown on the plans, or as ordered, by refilling to the required elevation with approved material which shall be placed in layers of not over 6 inches in depth and compacted until firm and solid.

3.12 EXTRUDED CURB (When indicated on the Contract Drawings)

Extruded Concrete Curbing: The grading limits shall be further modified, if necessary, to produce concrete that after extrusion has well defined web marks of water on the surface and is free of surface pits larger than 3/16" diameter. The concrete shall be of such consistency that after extrusion it will maintain the shape of the curb section without support or slumping. It shall contain the maximum amount of water that will permit this result.

In advance of placing the curbs on the surface of the pavement, the pavement shall be thoroughly cleaned and the adhesive shall be applied. The pavement shall be cleaned, if necessary, by abrading and/or high pressure water washing, so as to assure removal of all dust, loose material and/or oil.

The extruded curb shall be bonded to the existing pavement by using an adhesive. In advance of placing the curbs on the pavement the surface of the pavement shall be thoroughly cleaned and the adhesive shall be applied. The pavement shall be cleaned if necessary by abrading and/or high pressure water washing so as to assure removal of all dust, loose material and/or oil. A two component epoxy or suitable concrete adhesive designed to bond fresh concrete to existing pavement shall be used.

The top of the finished curb must be true to line. The curb will follow the contour of the pavement. The curb must be free of humps and sags. Control joints shall be cut as soon as possible through one-third of the cross section of the fresh concrete. The joint shall be tooled and finished to a neat uniform appearance. The control joint shall be installed at nine (9) foot intervals and more often on radii so as to minimize shrinkage cracking.

The finished curb will be coated with a curing compound, which has been designed to seal the surface and form a water proofing membrane to retard the loss of water from the fresh concrete. The manufacture's instructions must be followed.

END OF SECTION

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SECTION 32 31 21

ALUMINUM LOUVER FENCING AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Ornamental fixed louver modular fencing panels fabricated with extruded aluminum louvers and flat aluminum bars including extruded aluminum fence posts and aluminum louver gates.

B. Related sections:

1. Division 3 Section - Cast-in-Place Concrete: Concrete footings for support of fence posts.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM) Publications:

1. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

2. ASTM B221 - Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.

3. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

4. ASTM D822 - Tests on Paint and Related Coatings Using Filtered Open-Flame Carbon-Arc Exposure Apparatus.

5. ASTM D2794 - Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).

6. ASTM D3363 - Test Method for Film Hardness by Pencil Test.

1.3 SUBMITTALS

A. Provide in accordance with Section 01 33 00 - Submittal Procedures:

1. Product data for components and accessories.

2. Shop drawings showing layout, dimensions, spacing of components, and anchorage and installation details.

3. Sample: [8 by 10 inches] [203 by 254 mm] minimum size sample of fence panel illustrating design, fabrication workmanship, and selected color coating.

4. Copy of warranty specified in Paragraph 1.4 for review by Architect.

1.4 WARRANTY

A. Provide in accordance with Section 01 77 00 - Closeout Procedures:

1. 10 years warranty for factory finish against cracking, peeling, and blistering under normal use

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ametco Manufacturing Corporation, 4326 Hamann Parkway, P.O. Box 1210, Willoughby, Ohio 44096; 800-362-1360.

B. LouvreTec USA, Inc, 725 East Figueroa Street, Santa Barbara, CA 93103; 805-966-1977

C. American Fence Company, 15255 Industrial Road, Omaha, NE 68144; 402-896-0692.

2.2 MATERIALS

A. Extruded aluminum: ASTM B221, Alloy 6063, Temper T-6.

B. Sheet aluminum: ASTM B209 6063, Temper T-6.

C. Grout: Non-shrink type, pre-mixed compound consisting of non-metallic aggregate, cement, and water reducing and plasticizing additives.

2.3 FENCE SYSTEM

A. Type: Ornamental fencing system consisting of horizontal, fixed louver, modular fence panels fabricated with extruded aluminum framing bars and supported by extruded aluminum fence posts; Aluminum Fixed Louver Fencing: Extruded tubular aluminum blades providing 80 percent visual blocking as manufactured by mentioned manufacturers listed.

B. Fence panel:

1. Fixed louver blades: Extruded tubular aluminum louver blades, inclined at 45 degrees, and spaced at [2.83 inches] [72 mm] and to provide 80 percent direct

visual screening.

a. Size: [1/2 by 4 inches] [13 by 102 mm].

b. Material thickness: [0.09 inch] [2 mm].

2. Framing bars: Extruded aluminum flat bars welded to ends of louvers.

3. Panel height: As indicated on Drawings.

4. Panel width: As recommended by manufacturer.

C. Posts:

1. 3”x3” extruded tubular aluminum sections with solid aluminum caps.

2. Length: As indicated on Drawings.

3. Installed height of fence posts to match gate posts.

2.4 GATES

A. Provide gates of type and size indicated on Drawings. Equip gates with manufacturer's standard hardware as required for complete functional operation, including gate lock for open and closed positions.

B. Type: Hinged swinging double gates.

1. Construction: Welded frame fabricated from extruded aluminum tubing as recommended by manufacturer with aluminum fixed louver panels to match fencing material. Frame configuration shall be as indicated on Drawings and approved shop drawings.

2. Nominal size:

a. Gate opening: ± 16 feet

b. Gate: Two gates ± 8 feet wide by ± 6 feet high. Exact height to be determined by shop drawings.

c. Hardware:
1.) Hinges: Size and type as determined by manufacturer. Provide 2 hinges for each leaf up to 6 feet high and 1 additional hinge for each additional [24 inches] or fraction thereof.
2.) Latch: [3/4 inch] diameter slide bolt to accommodate padlock.
3.) For double gates provide padlockable [5/8 inch] diameter center cane bolt assembly and stike.

2.5 ACCESSORIES

A. Fasteners: Stainless steel bolts of type, size, and spacing as recommended by fence manufacturer for specific condition.

2.6 FACTORY FINISH

A. Aluminum fence panels and posts shall receive polyester powder coating. [Large gate panels shall be coated with 2-part polyurethane coating.]

B. Polyester powder coating: Electrostatically applied colored polyester powder coating heat cured to chemically bond finish to metal substrate.

3. Minimum hardness measured in accordance with ASTM D3363: 2H.

4. Direct impact resistance tested in accordance with ASTM D2794. Withstand 160 inch-pounds.

5. Salt spray resistance tested in accordance with ASTM B117: No undercutting, rusting, or blistering after 500 hours in 5 percent salt spray at 95 degrees F and 95 percent relative humidity and after 1000 hours less than [3/16 inch] [5 mm] undercutting.

6. Weatherability tested in accordance with ASTM D822: No film failure and 88 percent gloss retention after 1 year exposure in South Florida with test panels tilted at 45 degrees.

C. Polyurethane coating: 1.0 mil dry film thickness of coating of test panel cured 30 minutes at 180 degree F and aged 14 days shall resist the following test conditions without failure:

1. 5 percent salt spray for 500 hours.

2. 100 percent relative humidity for 1000 hours.

3. Water immersion for 100 hours.

4. 20 double rubs with cloth saturated with either lacquer thinner, acetone, MEK, gasoline, xylene.

5. Exposure to lubricating oils, hydraulic fluids, and cutting oils.

6. 16 cycles of 24 hours at 100 percent humidity, 24 hours at 10 degrees F, and 24 hours at 77 degrees F.

7. Hardness: H to 2H.

8. Flexibility: [1/8 inch] [3 mm] conical mandrel.

D. Color: Selected by Architect from manufacturer's standard range.

PART 3 – EXECUTION

3.1 PREPARATION

A. Prior to fabrication, field verify required dimensions.

B. Cast concrete footings in accordance with Division 3 Section - Cast-in-Place Concrete as detailed on Drawings and approved shop drawings.

1. Minimum footing diameter:

a. Terminal and gate posts: per manufacturer’s instructions

b. Intermediate line posts: per manufacturer’s instructions

2. Allow minimum embedment of posts per manufacturer’s instructions.

3. Allow minimum concrete beneath post bottom per manufacturer’s instructions.

C. Install fence posts in concrete footing per manufacturer’s instructions.

3.2 INSTALLATION

A. Install fencing in accordance with manufacturer's installation instructions and approved shop drawings.

B. Install fence posts plumb and level by setting post in footing per manufacturer’s instructions.

C. Do not install bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.

D. Secure fence panels with countersunk stainless steel bolts, per manufacturer’s instructions

E. Gates:

1. Install gates and adjust hardware for smooth operation.

2. Provide concrete center foundation depth and drop retainers at center of double swinging gate openings.

3. After installation, test gate and operator. Open and close a minimum of five

times. Correct deficiencies and adjust.

F. Touch-up damaged finish with paint supplied by manufacturer and matching original coating.

END OF SECTION

SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Lawns
   2. Planting soil mixes
   3. Seed bed preparation
   4. Seeding

B. Related Sections include the following:

   1. Division 01 Section "Project Management and Coordination" for on-site pre-installation conferences.
   2. Division 02 Section "Site Clearing" for topsoil stripping and stockpiling.
   3. Division 32 Section "Exterior Plants"

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil as indicated by the grading plan.

B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

C. Planting Soil: Native or imported topsoil, manufactured topsoil, or stockpiled surface soil that, when mixed with soil amendments, results in a planting medium capable of supporting healthy, vigorous plant growth.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill immediately beneath planting soil.

E. Disturbed Area: Any area within the project site that has been negatively altered by construction activities. Disturbed areas include but are not limited to areas that have:

been compacted, been tracked with heavy equipment, been used as staging or parking areas, been contaminated with fuels, lubricants, adhesives, fertilizers, paints or any other materials detrimental to plant growth.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for lawn, native wildflowers, and detention basin perennials grasses, identifying source, with name and telephone number of supplier.

C. Testing for Subgrade, Topsoil Mixes, and Permeable Soil Mixes: Testing is required at the following intervals:

1. Testing of individual components for planting soil mixes.
2. After test results for the composed organic material have been accepted, create sample Amended Top Soil Mix and perform tests described in Article 1.5, C.
3. If the Soil Scientist or Landscape Architect deems it necessary to adjust the soil mix, retest new mix until results are accepted.
4. Quality assurance Samples: After the test results for planting soil mixes have been accepted, and during the placement of planting soil mix, test every 100 cubic yards of planting soil mix delivered to the job site.
5. Testing of Subgrade: Prior to placement of the Soil Mix, coordinate the testing of the subgrade with the contractor as follows:
   a. Density Tests: ASTM D1556 Density of soil and rock in place using “Sand Cone Method”. ASTM D698 Test Method for laboratory compaction characteristics of soil using Standard Effort.
      1) In-place density tests shall be carried out at a rate of one test per 1,000 square feet of plant bed area.

D. Sources for Soil Components and Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of planting soil mixes.

1. Landscape Architect and Soil Scientist shall have the right to reject any soil supplier.
2. Planting Soil Mix supplier shall have a minimum of five years experience at supplying custom planting soil mixes.
3. Submit supplier name, address telephone and fax numbers and contact name.
4. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project.

E. Qualification Data: For landscape installer.

F. Planting Schedule: Indicating anticipated planting dates for each type of planting.

G. Maintenance Instructions: Recommended procedures to be established by Owner in consultation with landscape architect for maintenance of lawn, native wildflowers, and detention basin grasses and wildflowers during a calendar year. Submit before expiration of required maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when exterior planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Planting Soil Mix Analysis: Furnish Planting Soil Mix analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Report suitability of Planting Soil Mix for plant growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory soil mix.

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

B. Planting Soil Mix should not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall or is frozen. Planting Soil Mix should be handled only when the moisture content is less than at field capacity. The Landscape Architect shall be consulted to determine if the soil is too wet to handle.

C. Store and handle packaged materials in strict compliance with manufacturer’s instructions and recommendations. Protect all materials from weather, damage, injury and theft.

D. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from Construction Manager. Deliver materials only after preparations for placement of planting soil have been completed.

E. Prohibit vehicular and pedestrian traffic on or around stockpiled Planting Soil Mix.

1.7 SCHEDULING

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Lawn

a. Spring Seeding: April 1 – May 15th
b. Fall Seeding: September 1 – October 15th

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.8 LAWN MAINTENANCE

A. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Seeded Lawns: 90 days from date of Substantial Completion.

a. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.

B. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn.

1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch. Anchor as required to prevent displacement.

C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches (100 mm).

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.

D. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow grass 1-1/2 to 2 inches (38 to 50 mm) high.

E. Lawn Post fertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to lawn area.

F. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep plant community uniformly moist.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.

G. Weeding: Monitoring and controlling weeds is critical in the first and second years of establishment. Identifying invasive species and spot spraying with an approved herbicide shall be performed by a licensed professional in the first two weeks of June and in the last two weeks of September throughout the entire maintenance period.

PART 2 - PRODUCTS

2.1 SEED MIXES

A. Lawn Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

1. Products: Subject to compliance with requirements provide the following:

a. Sun Mix - Super Seed Store’s mix number SS5000
20% Bedazzled Kentucky Bluegrass
20% Bewitched Kentucky Bluegrass
20% Midnight II Kentucky Bluegrass
20% Zodiac Chewings Fescue
20% Amazing GS Perennial Ryegrass

b. Shade Mix - Super Seed Store’s mix number SS6000
20% America Kentucky Bluegrass
20% Zodiac Chewings Fescue

20% Intrigue Chewings Fescue
20% Garnet Creeping Red Fescue
20% Spartan II Hard Fescue

B. Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

C. Seed Carrier: Clean, dry sand applied at a rate of 1 lb per lb of seed.

2.2 AMENDED TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 6.8, a minimum of 5-8% percent organic material and 20-30% silt and clay by weight; free of stones 1 inch (25 mm) or larger in any dimension and other extraneous materials harmful to plant growth.

1. Topsoil Source: Amend existing in-place surface soil to produce topsoil. Verify suitability of surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

a. Surface soil may be supplemented with imported or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs or marshes.

B. Topsoil shall conform to the following mechanical analysis:

1. Analysis shall be determined by the buoyoucous hydrometer or decantation method and shall indicate no more than 15% clay and 35% silt in the sample.
2. A dry sieve analysis shall be used on the sample to determine the five sand fractions as specified by the USDA textural classification system. The sample shall contain 60-70% sand by weight. The coarse sand fraction (0.5 mm – 1.0 mm diameter range particles) shall consist of at least 30% and no more than 40% of the sand fraction. No more than 3% of the sample shall be gravel (> 2.0 mm diameter particles).
3. Soil salinity by the electrical conductivity method shall not exceed 2.0 millimhos per centimeter at 25° Celsius as determined by the saturated soil test method described in USDA circular No. 982.
4. The Contractor may amend sandy loam topsoil with approved materials and by approved methods to meet the above specification.

C. The following items shall be added to the above mix:
1. Bonemeal per Penn State Native Grass Establishment soil analysis recommendations.
2. Commercial fertilize per Penn State Native Grass Establishment soil analysis recommendations.

3. Controlled release fertilizer per Penn State Native Grass Establishment soil analysis recommendations.
4. Two pounds water absorbent polymer per cubic yard of soil mixture, or as recommended by manufacturer.
5. Ground limestone as required for specified pH
6. Processed Sand:

    a. Sand shall be tested for particle size distribution (USGA) very coarse to very fine categories. Evenly graded sand with equal percentage of coarse, medium, and fine particle size should be avoided.
    b. There shall be no more than 15% combined silt and clay.
    c. There shall be no more than 30% fine sand.
    d. There shall be no more that 10% very fine sand.

D. Testing Methods

1. ASTM F1632-B Standard Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis shall be used for measurement of particle size distribution and the coefficient of uniformity.
2. Performance Testing: ASTM F1815 Standard Test Method for Saturated Hydraulic Conductivity shall be used to determine infiltration rate.
3. Required Infiltration rate > 1.0 (inches per hour)

E. Compost

1. Compost shall be derived from organic wastes such as leaf and yard waste residues and meet all State Environmental Agency requirements. The product shall be well composted, and contain material of a generally humus nature capable of sustaining growth of vegetation, with no materials toxic to plant growth.
2. Compost shall have the following properties:

Parameters	Range
ph	5.5 – 8.0
Moisture Content	35% – 55%
Soluble Salts	4.0 mmhos (dS)
C:N ratio	10 – 30:1
Particle Size	< 3/4″
Organic Matter Content	> 25%
Bulk Density	< 1400 lbs./cubic yard
Foreign Matter	< 1% (dry weight)

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:

1. Class: Class T, with a minimum 99 percent passing through No. 8 (2.36-mm) sieve and a minimum 75 percent passing through No. 60 (0.25-mm) sieve.
2. Provide lime in form of dolomitic limestone.

B. Sand: Clean, washed, natural or manufactured, free of toxic materials.

1. Gradation for sand:

Material	Particle Size	Maximum %
Rocks and stones	>3.40 mm	0%
Gravel, clods	3.4 mm – 2.0 mm	≤ 3%
Very coarse sand	2.0 mm – 1.0 mm	0%
Coarse sand	1.0 mm - 0.5 mm	≤ 25%
Medium sand	0.5 mm – 0.25 mm	≤ 10%
Fine sand	0.25 mm – 0.15 mm	≤ 30%
Silt / clay	<0.05 mm	≤ 50%

Sieve Size	Percent Passing
25.0 MM (1")	100
6.3 mm	90 – 99 shall be gravel
2.0 mm	80 – 90 breakpoint of sand and gravel
0.75 mm	60 – 80 breakpoint of coarse and fine sand
0.074	25 – 50 breakpoint of sand and silt
0.005	5 – 15 breakpoint of silt and clay

2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch (12.5-mm) sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

2.5 PLANTING ACCESSORIES

A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.6 FERTILIZER

A. Bonemeal: Commercial, raw or steamed, finely ground with the following N-P-K (Nitrogen-Phosphorus-Potassium) analysis: 4-12-0.

B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.7 FILTER FABRIC

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Mirafi 140N as manufactured by Mirafi, Inc., Box 240967, Charlotte, NC 28224
2. US 200 Woven Geotextile, US Fabrics, Inc., 3904 Virginia Avenue, Cincinnati, OH 45227
3. GeoTex 2X2HF, Propex Operating Company, LLC; 4019 Industry Drive, Chattanooga, TN 37416

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive lawns, grasses and other seeded perennials for compliance with requirements and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 LAWN PREPARATION

A. Limit subgrade preparation to areas to be planted. Contractor shall establish all subgrades at elevations necessary to meet the grading plan's indicated finished grades after minimum planting soil mix quantities for lawn areas are installed.

B. In areas where proposed grade is higher than existing grade approved compacted fill may be used where the difference in grade is in excess of 6 inches (150mm).

1. Fill material shall be placed in 6 inch lifts and compacted to 85% dry density.
2. Fill material shall be placed in quantities necessary to support planting soil at finish grade after natural settlement.

C. Undisturbed Areas: If lawns are to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare surface soil as follows:

1. Using a licensed spray technician, apply two applications of an approved herbicide, such as Glyphosate, to all vegetated areas intended to receive lawn. Separate applications by a minimum of two weeks but no more than 18 days.
2. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
3. Till surface soil to depth indicated on the drawings and remove stones larger than 1 inch (25 mm) in any dimension as well as sticks, trash, and other extraneous matter. With a tiller, thoroughly mix topsoil and soil amendments into indicated depth of existing soil in quantities necessary to meet planting soil mix specification for lawn areas and finish grade prior to loosening procedures. Till

soil to a homogeneous mixture of fine texture. Rake surface to create a smooth, even grade.

a. Apply fertilizer directly to surface soil before loosening.

4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Disturbed Areas: Till subgrade, existing soil or fill with a tiller to depth indicated on the drawings. Remove stones larger than 1 inch (25 mm) in any dimension as well as sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.

a. Delay mixing fertilizer with planting soil if planting will not proceed within 1 week.
b. Mix lime with dry soil before mixing fertilizer.

3. Spread planting soil mix to depth indicated on the drawings but not less than required to meet finished grade after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

a. Prior to spreading minimum planting soil depth, thoroughly till topsoil and soil amendments into loosened subgrade, existing soil or fill to depth indicated on drawings in quantities necessary to meet planting soil mix specification for lawn areas. After subgrade is amended, continue spreading remaining planting soil mix to depth indicated on the drawings. Till soil to a homogeneous mixture of fine texture. Rake surface to create a smooth, even grade.

E. Finish Grading: Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.

F. Moisten prepared seeding areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

G. Scarify prepared surface of seed bed with a rake to a depth of ½ inch (13mm).

H. Protect prepared seed bed areas from compaction after preparation by isolating said areas through installation of orange construction fence. See tree protection specifications for proper installation instructions.

I. Restore areas if eroded or otherwise disturbed after finish grading and before planting.

J. Disturbed Areas: Till subgrade, existing soil or fill with a tiller to depth indicated on the drawings. Remove stones larger than 1 inch (25 mm) in any dimension as well as sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply fertilizer directly to subgrade before loosening.
2. Thoroughly blend planting soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil mix.
   a. Delay mixing fertilizer with planting soil if planting will not proceed within 1 week.
   b. Mix lime with dry soil before mixing fertilizer.
3. Spread planting soil mix to depth indicated on the drawings but not less than required to meet finished grade after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
   a. Prior to spreading minimum planting soil depth, thoroughly till topsoil and soil amendments into loosened subgrade, existing soil or fill to depth indicated on drawings in quantities necessary to meet planting soil mix specification for native seeding areas. After subgrade is amended, continue spreading remaining planting soil mix to depth indicated on the drawings. Till soil to a homogeneous mixture of fine texture. Rake surface to create a smooth, even grade.

K. Finish Grading: Grade seeding areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.

L. Moisten prepared seeding areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

M. Scarify prepared surface of seed bed with a rake to a depth of ½ inch (13mm).

N. Protect prepared seed bed of lawn and meadow areas from compaction after preparation by isolating said areas through installation of orange construction fence. See tree protection specifications for proper installation instructions.

O. Restore areas if eroded or otherwise disturbed after finish grading and before planting.

P. If the landscape architect determines that planting areas have become contaminated or excessively compacted due to construction activities, additional soil mitigation procedures are necessary.

Q. Contractor shall establish all subgrades at elevations necessary to meet the grading plan's indicated finished grades after minimum planting soil quantities are installed.

R. All Proposed Grades: If proposed grades are within 36 inches of contaminated or severely compacted soils at existing grade, remove the top 12 inches of soil and install approved, compacted fill and planting soil mix to depth required to support appropriate plant growth. Contractor shall legally dispose of all contaminated soils off Owner's property.

3.4 LAWN SEEDING

A. Sow seed with a spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.

B. Sow seed at 5 lbs per 1,000 sq. ft.

C. Rake seed lightly into top 1/8 inch (3 mm) of topsoil, roll lightly, and water with fine spray.

D. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 6 hours of completing seeding operations. Soak and scatter uniformly to a depth of 3/16 inch (4.8 mm) and roll to a smooth surface.

E. Continue protection of seeded lawn areas after seeding through maintenance and reinstallation of any orange construction fence removed or compromised as the result of seeding operations or otherwise. Keep orange construction fence in place for 4 weeks or until satisfactory vegetation coverage has been achieved as approved by the engineer or the engineer's representative.

3.5 SATISFACTORY LAWNS

A. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 95 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 3 by 3 inches (75 by 75 mm).

B. Reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.6 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by lawn work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period and remove after lawn is established.

C. Remove erosion-control measures after grass establishment period.

END OF SECTION

SECTION 32 93 00

EXTERIOR PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Trees
2. Shrubs
3. Herbaceous Plants
4. Weed control barriers
5. Tree Staking & Staples
6. Landscape edgings
7. Mineral Mulch
8. Organic Mulch
9. Misc. planting products

B. Related Sections include the following:

1. Division 02 Section "Site Clearing" for protection of existing trees and planting, topsoil stripping and stockpiling, and site clearing.

2. Division 32 Section "Irrigation" for temporary and permanent irrigation system.

3. Division 32 Section "Lawns and Grasses" for all Soils and protection of installed seeding and planting.

4. Division 33 Section "Subdrainage" for below-grade drainage of landscaped areas, paved areas, and wall perimeters.

1.3 DEFINITIONS

A. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by

ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.

B. Balled and Potted Stock: Exterior plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of exterior plant required.

C. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

D. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted exterior plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of exterior plant.

E. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

F. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

I. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

J. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

K. Woody Plants: a plant having hard lignified tissues or woody parts especially stems, typically including: trees, shrubs, broadleaf and coniferous evergreens.

L. Herbaceous Plant: a plant lacking a permanent woody stem, typically including: vines, groundcovers, perennials, biennials and annuals.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples for Verification: For each of the following:

1. Plant Materials: Provide product data that Include quantities, sizes, quality, and sources for plant materials.

2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. Include photos for all container plant material. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

3. Nursery Tagging: The Contractor shall pre-tag all balled and burlapped plant materials at a nursery for tagging by the Landscape Architect. This will be accomplished in two steps:
   a. Step 1 - Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished and an angle that depicts that row that it is grown. Supply the age of the plant material and root pruning practices of the nursery. Include a scale rod or other measuring device in each photograph.
   b. Step 2 – The Landscape Architect shall visit the nursery to verify tagging by the Contractor.

4. Edging materials and accessories, including standard corner pieces, of manufacturer's standard size, to verify color selected and corner condition.

5. 6 oz. of mineral mulch for each color, size and texture of stone required, in labeled plastic bags. Label to identify type and source of mineral mulch. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of color, texture, and makeup of the material.

6. 6 oz. of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.

7. 1 tree staple of manufacturer's standard size, to verify quality of product.

8. 6”x 6” tile of Non-woven geotextile filter fabric.

C. Planting Notices and Schedules:
   1. Within (15) calendar days of the anticipated date of planting, submit to Owner and Landscape Architect invoices or certificates of deposit from nurser(ies) guaranteeing timely delivery of all specified and tagged plant materials. If plant materials are unavailable at the time of submittal, Contractor shall contact Landscape Architect to determine acceptable alternatives.

2. Submit to Owner and Landscape Architect a schedule itemizing landscape planting work to be performed. This schedule shall be submitted (30) calendar days before the planting window(s) open.
   a. Include in this schedule all anticipated dates for commencement and sequencing of tree planting work, including, but not limited to, selections and tagging, layout and layout approval, placement of trees, and commencement of maintenance period.

D. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:

1. Manufacturer's certified analysis for standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

E. Qualification Data: For landscape Installer.

F. Material Test Reports: For existing surface soil and imported topsoil.

G. Maintenance Instructions: Recommended procedures to be established by Owner in conjunction with Landscape Architect and Contractor for maintenance of all exterior plants during a calendar year. Maintenance instructions to be compiled in a 3-ring binder describing pruning, fertilizing, and watering instructions for each plant type installed. Submit before expiration of required maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when exterior planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for plant growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory topsoil.

D. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."

E. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements from trunk at breast height. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

F. Observation: Landscape Architect may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of sources of planting materials a minimum of (30) calendar days in advance of delivery to site.

G. Pre-installation Conference: Contractor shall organize a pre-installation conference with the Landscape Architect to discuss project expectations, work scheduling, quality of craftsmanship and material sourcing. Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver exterior plants freshly dug.

1. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

B. Do not prune trees and shrubs before delivery, except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

C. Handle planting stock by root ball.

D. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants on the ground in a “shade house”, erected by the Contractor, with root balls well protected with soil, wet peat, and other acceptable material. Protect balls and roots from freezing, sun, drying winds, and/or mechanical damage. Water as necessary until planted. In addition:

1. Heel-in bare-root stock. Soak roots in water for two hours if dried out.

2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of exterior plants stored on-site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.7 COORDINATION

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Deciduous Woody Plants: April 1 – May 15, and September 30 – December while the soil is in a workable condition.
2. Evergreen Plants: April 1 – start of new growth in June, and September 1 – October 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

C. Coordination with Lawns: Plant trees and shrubs after finish grades are established and before planting lawns, unless otherwise acceptable to Landscape Architect.

1. When planting trees and shrubs after lawns, protect lawn areas and promptly repair damage caused by planting operations.

D. Coordination with hardscape: In garden areas surrounded by hardscape, ensure that large plant material and Garden Boulders are delivered to gardens before installation of surrounding hardscapes.

1. When planting trees and shrubs after hardscapes have been installed, protect finished surfaces and promptly repair damage caused by planting operations.

E. Fall Digging Hazard: Plant material indicated on Drawings as a “Fall Digging Hazard” are to be dug in the spring due to poor survival rates when dug in the fall for transplanting. Coordinate Planting Schedule with Landscape Architect.

1.8 WARRANTY

A. Special Warranty: Warrant the following exterior plants, for the warranty period indicated, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by Owner, or incidents that are beyond Contractor's control.

1. Warranty Period for Trees and Shrubs: One year from date of Substantial Completion.

2. Warranty Period for Herbaceous Plants: Six months from date of Substantial Completion.
3. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.
4. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
5. A limit of one replacement of each exterior plant type will be required, except for losses or replacements due to failure to comply with requirements.

1.9 MAINTENANCE

A. Trees and Shrubs: Maintain for the following maintenance period by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings.

1. Maintenance Period: 12 months from date of Substantial Completion.

B. Herbaceous Plants: Maintain for the following maintenance period by watering, weeding, fertilizing, and other operations as required to establish healthy, viable plantings:

1. Maintenance Period: 6 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL PLANT REQUIREMENTS

A. Provide balled and burlapped or container grown plants as indicated in planting schedule.

B. Origin: All plant material shall be obtained from sources within 100 miles of project site.

C. Plants with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; specimens which have been grown with the root flare beneath the surface of the surrounding soil or with stem girdling roots will be rejected.

D. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

E. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.2 TREE AND SHRUB MATERIAL

A. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Grade: Provide trees and shrubs of sizes and grades complying with ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Label at all trees and shrubs of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

2.3 SHADE AND FLOWERING TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
   1. Branching Height: One-third to one-half of tree height unless otherwise noted on Drawings.

B. Small Upright or Spreading Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:

   1. Stem Form: Multistem, clump, with three or more main stems.

C. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:

   1. Stem Form: Clump.

2.4 DECIDUOUS SHRUBS

A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.

1. Provide balled and burlapped or container grown trees as indicated in planting schedule.

2.5 CONIFEROUS EVERGREENS

A. Form and Size: Specimen-quality, exceptionally heavy, tightly knit, symmetrically shaped coniferous evergreens

2.6 BROADLEAF EVERGREENS

A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.Retain one or more of four options in subparagraph below.

2.7 HERBACEOUS PLANTS

A. Herbaceous Plants: Provide herbaceous plants of species, sizes and requirements indicated on Drawings, established and well rooted in pots or similar containers, and complying with ANSI Z60.1.

2.8 TOPSOIL, AMMENDMENTS AND PLANTING SOIL

A. (SEE SECTION 329200 – TURFS AND GRASSES FOR ALL SOIL INFORMATION)

2.9 WEED CONTROL BARRIER

A. (SEE SECTION 329200 – TURFS AND GRASSES FOR ALL SOIL INFORMATION)

2.10 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 8.

2.11 MINERAL MULCH

A. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:
   1. Mineral Mulch:
      a. Type: Eastern Rounded Riverstone - washed
      b. Size Range: 2 inch maximum, 1 inch minimum.
      c. Color: Mixed greys and blues, acceptable to Landscape Architect.

d. Origin: Mineral mulch must be obtained from a single source within 500 miles of project site.

2.12 ORGANIC MULCH

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of garden beds, trees and shrubs, consisting of the following:
1. Type: Wood and Bark Chips
2. Size Range of Pieces: 3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum
3. Color: Natural brown.

2.13 TREE STAPLES

A. Tree Staples: Staple all trees 2” and greater in caliper and 6’ or greater in height, using Tree Staple brand staples or approved equal. Tree Staples are composed of uncoated, cold-rolled, plain carbon steel. Install according to manufacturer’s instructions and as indicated in drawings.

B. Tree staples shall be sized according to the following chart:

Tree Caliper	Tree Staple Model	# of Staples per Tree
1" - 2"	TS24 (24")	2 with up to a 16" root ball
2" - 4"	TS36 (36")	2 with a 24" root ball
4" - 6"	TS42 (42")	3 with a 30"+ root ball
6" - 8"	TS48 (48")	3 with a 36"+ root ball

2.14 LANDSCAPE EDGINGS

A. Plastic Edging: Standard commercial premium blend polyethylene edging, with corrugated side baffle and extra heavy top bead, fabricated in standard lengths.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Sure-Loc Edgings Inc.
b. Perma-Loc
c. Olyola Edgings Inc.

2. Edging Size: 1 inch Round Bead Top (6.4 mm) wide by 5 inches (125 mm) deep.
3. Weight: 7lbs per strip
4. Stakes: Standard Plastic
5. Accessories: Standard plastic connectors and corner connectors.
6. Color: Black

2.15 PESTICIDES

A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.16 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

B. Trunk-Wrap Tape: Two layers of crinkled paper cemented together with bituminous material, 4-inch- (100-mm-) wide minimum, with stretch factor of 33 percent.

C. Burlap: Non-synthetic, biodegradable.

D. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple exterior plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before planting. Make minor adjustments as required.

D. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

E. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation. Remove wrapping once installed.

3.3 PLANTING BED ESTABLISHMENT

A. Loosen subgrade of planting beds to a minimum depth indicated on drawings. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply superphosphate fertilizer directly to subgrade before loosening.

2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting bed. See Specification 329200 Turf and Grasses for Amended Topsoil.

    a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    b. Mix lime with dry soil before mixing fertilizer.

B. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Ensure that finished grade is flush with adjacent surfaces, including steel edgings, curbs and walking surfaces.

C. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.4 TREE AND SHRUB EXCAVATION

A. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.

1. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
3. If drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.

B. Subsoil removed from excavations may not be used as backfill.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch diameter holes into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

3.5 TREE AND SHRUB PLANTING

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball

to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set balled and burlapped stock plumb and in center of pit or trench with root flare 1-inch above adjacent finish grades.

1. Remove burlap and wire baskets from tops of root balls and partially from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, add Mycorrhizal inoculation and water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

D. Set container-grown stock plumb and in center of pit or trench with root flare 1 inch above adjacent finish grades.

1. Carefully remove root mass from container without damaging root mass or plant.
2. Place planting soil mix around root mass in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, add Mycorrhizal inoculation and water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

E. Set fabric bag-grown stock plumb and in center of pit or trench with root flare 1 inch above adjacent finish grades.

F. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
1. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, add Mycorrhizal inoculation and water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

G. Organic Mulching: Apply organic mulch at thickness indicated in drawings, extending 12 inches beyond edge of planting pit or trench. Do not place mulch within 3 inches of trunks or stems.

3.6 FORMAL PLANT ARRANGEMENT

A. Where perennial massings, formal arrangements or consecutive order of plants are shown on Drawings, place material to assure symmetry and regularity of spacing in planting.
   1. Variation of linear arrangement for trees: Do not exceed variation of linear arrangement by more than 3 inches in 100 feet, as measured from center of trunk.
   2. Variation of linear arrangement for Shrubs: Do not exceed variation of linear arrangement by more than 6 inches in 100 feet, as measured from center of plant mass.
   3. Variation of linear arrangement for perennials: Do not exceed variation of linear arrangement by more than 3 inches in 50 feet, as measured from center of plant mass

3.7 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise indicated by Landscape Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

3.8 TREE STAPLING

A. Leaving burlap intact, heel the plant's root ball into place.

B. Remove plastic safety caps from Tree Staples™ and set aside.

C. Set each Tree Staple opposite the other and against the outside edge of the root ball. The shorter prong should be positioned over the root ball, halfway between the trunk and the ball's outer edge.

D. Using a sledgehammer, drive each Tree Staple into the ground until the cross bar is recessed one to two inches below the surface of the root ball. Alternate between hitting either of the prongs to insure that the Tree Staples are completely below-grade.

E. Place safety caps on exposed ends.

F. Cut back burlap, leaving material under cross bars.

3.9 MULCHING

A. Mulch backfilled surfaces of planting beds and other areas indicated.

1. Organic Mulch: Apply organic mulch to thickness indicated in drawings, and finish level with adjacent finish grades. Do not place mulch against plant stems.

2. Mineral Mulch:
   a. Install filter fabric before installing mineral mulch, according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches and secure seams with galvanized pins. Trim edges below finished grade as indicated in drawings. No portion of filter fabric shall be visible after installation is complete.
   b. Apply mineral mulch to thickness indicated in drawings, and finish level with adjacent finish grades. Do not place mulch against plant stems. Ensure that mineral mulch covers filter fabric completely and obscures it from view.

3.10 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

3.11 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

3.12 DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION

SECTION 32 96 00

TRANSPLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes transplanting non-nursery-grown trees by tree spade.

1.2 DEFINITIONS

A. General: See definitions in ANSI A300 (Part 6) and in ANSI Z60.1 pertaining to field-grown trees, except as otherwise defined in this Section.

B. Caliper: Diameter of a trunk as measured by a diameter tape at a height 6 inches (150 mm) above the root flair for trees up to, and including, 4-inch (100-mm) size at this height; and as measured at a height of 12 inches (300 mm) above the root flair for trees larger than 4-inch (100-mm) size.

C. Root-Ball Depth: Measured from bottom of trunk flare to the bottom of root ball.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Norwalk Community College.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Pruning Schedule: Written schedule prepared by arborist detailing scope and extent of pruning each tree in preparation for and subsequent to transplanting.

1.5 INFORMATIONAL SUBMITTALS

A. Certification: From arborist, certifying that transplanted trees have been protected during construction and that trees were promptly and properly treated and repaired when damaged.

B. Maintenance Recommendations: From arborist, recommended procedures to be established by Owner for care and protection of trees after completing the Work.

C. Existing Conditions: Documentation of existing trees indicated to be transplanted, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.

D. Tree-maintenance reports.

1.6 QUALITY ASSURANCE

A. Tree-Service Firm Qualifications: An experienced landscaping contractor or tree-moving firm that has successfully completed transplanting work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.

1. Arborist Qualifications: Certified Arborist as certified by ISA, licensed arborist in jurisdiction where Project is located, current member of ASCA, or registered Consulting Arborist as designated by ASCA.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy their natural shape.

B. Completely cover foliage when transporting trees while they are in foliage.

C. Handle trees by root ball. Do not drop trees.

D. Move trees after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after moving, set trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify final grade elevations and final locations of trees and construction contiguous with trees by field measurements before proceeding with transplanting work. Perform transplanting only after finish grades are established.

B. Seasonal Restrictions: Transplant trees during the following in-season periods:

1. Spring: Preferred Transplanting Time
   a. Early Spring While Tree is Dormant
   b. Suggested Dates – 3/1-4/15, weather dependent.
2. Summer: Not Recommended.
3. Fall: Not Recommended.

4. Winter: Not Recommended.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide tree maintenance by skilled employees of tree-service firm and as required in Part 3. Begin maintenance immediately after preparatory pruning and continue until plantings are healthy and well established but for not less than maintenance period below.

1. Maintenance Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Transplanted trees shall be healthy and resume vigorous growth within 18 months of transplanting without dieback due to defective extracting, handling, planting, maintenance, or other defects in the Work.

2.2 PLANTING MATERIALS

A. Backfill Soil: Excavated soil mixed with planting soil of suitable moisture content and granular texture for placing and compacting in planting pit around tree, and free of stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth.

1. Mixture: Well-blended mix of two parts excavated soil to one part planting soil.
2. Planting Soil: Planting soil as specified in Section 329200 "Lawns and Grasses”.

2.3 WATERING DEVICES

A. Watering Pipe: PVC pipe 4 inches (100 mm) in diameter, site-cut to length as required, and with snug-fitting removable cap.

B. Slow-Release Watering Device: Standard product manufactured for drip-irrigation of plants and emptying its water contents over a period of 2 to 9 hours; manufactured from UV-light stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

2.4 MISCELLANEOUS PRODUCTS

A. Organic Mulch: Shredded hardwood as specified in Section 329300 "Plants."

B. Mineral Mulch: Rounded riverbed gravel or smooth-faced stone as specified in Section 329300 "Plants."

C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

D. Burlap: Non-synthetic, biodegradable.

E. Pesticides: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended in writing by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

F. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: 5-gram tablets.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

G. Weed-Control Barriers:

1. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101 g/sq. m) minimum.
2. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

PART 3 - EXECUTION

3.1 PREPARATION

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning excavation.

B. Lay out individual transplant locations and areas for multiple plantings, and obtain Architect's acceptance of layout before transplanting.

C. Apply antidesiccant to trees uniformly, using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during extracting, handling, and transportation.

1. If deciduous trees are moved in full leaf, spray with antidesiccant before extracting and again two weeks after transplanting.

D. Wrap trees with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during extracting, handling, and transporting.

3.2 PREPARATORY PRUNING

A. Root Pruning: Perform preparatory root pruning under direction of arborist as far in advance of extracting each tree as the Project Schedule allows.

B. Crown Pruning (Tip Pruning):

1. Do not perform preparatory crown pruning (tip pruning).
2. Perform preparatory crown as directed by arborist. Follow procedures as specified in "Crown Pruning" Article.

3.3 EXCAVATING PLANTING PITS

A. General: Excavate under supervision of the arborist. Keep excavations covered or otherwise protected until replanting trees.

B. Subsoil and topsoil removed from excavations may not be used as planting soil.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees are encountered in excavations.

D. Seepage: Notify Architect if subsoil conditions evidence unexpected water seepage into tree-planting pits.

3.4 EXTRACTING TREES

A. General: Extract trees under supervision of the arborist.

B. Orientation Marking: Mark the north side of each tree with non-permanent paint before extracting.

C. Root-Ball Width: Minimum 10 inches (250 mm) of root-ball diameter, or least dimension for non-round root balls, for each inch (25 mm) of tree caliper being transplanted.

1. Out-of-Season Planting: If planting before or after the in-season period for tree, provide a minimum root-ball diameter of 12 inches (305 mm) for each inch (25 mm) of tree caliper being transplanted.

D. Root-Ball Depth: As determined by the arborist for each species and size of tree and for site conditions at original and planting locations.

E. Digging:

1. Dig and clear a pit with tree spade to the depth of the root system.
2. Cut exposed roots manually with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not paint or apply sealants on cut root ends.
3. Cover roots with burlap and keep them moist until planted.

F. Extracting with Tree Spade: Use the same tree spade to extract the tree as will be used to transport and plant the tree.

3.5 PLANTING

A. Planting Standard: Perform planting according to ANSI A300 (Part 6) unless otherwise indicated.

B. Before planting, verify that root flare is visible at top of root ball. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

C. Ensure that root flare is visible after planting.

D. Remove injured roots by cutting cleanly; do not break. Do not paint or apply sealants on cut root ends.

E. Orientation: Position the tree so that its north side, marked before extracting, is facing north in its new location.

F. Set tree plumb and in center of planting pit with top of root flare 1 inch (25 mm) above adjacent finish grades.

1. Use specified backfill soil for backfill.
2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
3. Redirect exposed root ends downward in backfill areas where possible. Hand-expose roots as required to bend and redirect them without breaking.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended by arborist. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. Watering Pipe: During backfilling, install watering pipe 4 feet (1220 mm) deep into the planting pit outside the root ball with top of pipe 1 inch (25 mm) above the mulched surface.

H. Planting with Tree Spade: Use the same tree spade for planting as was used to extract and transport the tree.

I. Slopes: When planting on slopes, set the tree so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 CROWN PRUNING

A. Prune branches as directed by arborist.

1. Prune to remove only injured, broken, dying, or dead branches. Do not prune for shape.
2. Do not remove or reduce living branches to compensate for root loss caused by cutting root system or to improve natural tree form.
3. Pruning Standards: Perform pruning according to ANSI A300 (Part 1).

3.7 TREE STABILIZATION

A. Stabilize tree as directed by arborist.

3.8 MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) and secure seams with galvanized pins.

B. Organic Mulch: Apply 2-inch (50-mm) average thickness of organic mulch extending 12 inches (300 mm) beyond edge of individual planting pit, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) of trunks or stems.

C. Mineral Mulch in Planting Areas: Apply 2-inch (50-mm) average thickness of mineral mulch extending 12 inches (300 mm) beyond edge of individual planting pit, and finish level with adjacent finish grades. Do not place mulch within 6 inches (150 mm) of trunks or stems.

3.9 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree and fill with water according to manufacturer's written instructions.

3.10 TREE MAINTENANCE

A. Perform tree maintenance as recommended by arborist. Maintain arborist observation of transplanting work.

B. Maintain trees by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Treat as required to keep trees free of insects and disease.

C. From time of preparatory root pruning measure soil moisture adjacent to edge of each root ball weekly. Record findings and weather conditions.

D. Fill areas of soil subsidence with backfill soil. Replenish mulch materials damaged or lost in areas of subsidence.

E. Apply treatments as required to keep tree materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

F. Pesticide Application: Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

G. Reports: Have arborist prepare monthly inspection reports.

3.11 REPAIR AND REPLACEMENT

A. General: Repair or replace transplanted trees and other plants indicated to remain or be relocated that are damaged by construction operations, in a manner recommended by the arborist and approved by Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours according to arborist's written instructions.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size and species as those being replaced.

3.12 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Except for materials indicated to be recycled, remove surplus soil, excess excavated material, waste materials, displaced plants, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 329600

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PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Furnishing and installing ductile iron water mains and fittings, and appurtenant valves and fittings, complete in place, as shown on the Drawings and as specified.

1.02 REFERENCES

A. ANSI/ASTM D2922 – Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

B. AWWA C104 – American National Standard for Cement-Mortar Lining for Cast-Iron and Ductile-Iron Fittings for Water.

C. AWWA C110 – American National Standard for Gray-Iron and Ductile-Iron Fittings, 2 in. through 48 in. for Water and Other Liquids.

D. AWWA C111 – American National Standard for Rubber Gasket Joints for Cast Iron and Ductile Pressure Pipe and Fittings.

E. AWWA C151 – American National Standard for Ductile-Iron Pipe, Centrifugally cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids.

F. AWWA C153 – American National Standard for Ductile-Iron Pipe Compact Fittings 3 Inch through 12 Inch for Water and Other Liquids.

G. AWWA C500 – Metal-Seated Gate Valves for Water Supply Service.

H. AWWA C502 – Dry-Barrel Fire Hydrants.

I. AWWA C550 – Protective Epoxy Interior Coatings for Valves and Hydrants.

J. AWWA C600 – Installation of Gray and Ductile Iron Water Mains and Appurtenances.

K. AWWA C651 – Disinfecting Water Mains.

1.03 SUBMITTALS

A. Submit data on the following:

1. Product Data: Provide data indicating pipe, fittings, valves, and pipe accessories.

2. Manufacturer's Installation Instructions: Indicate special procedures required to install the products specified.

3. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.05 DELIVERY, STORAGE AND HANDLING

A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.

B. Protection of utilities: Protect existing utilities as specified in Section 31 20 00 – Earth Moving.

C. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Engineer.

D. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no additional cost to the Owner.

1.06 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

1.07 REGULATORY REQUIREMENTS

A. Relation to sanitary sewer lines: Lay water lines at least 10 feet horizontally from any existing, or proposed, sewer lines if possible. If conditions prevent a lateral separation of 10 feet, a water line may be laid within 10 feet of a sanitary sewer if:

1. It is laid in a separate trench, or if it is laid in the same trench with the sanitary sewer line located at one side of a bench of undisturbed earth, and if;

2. In either case the elevation of the bottom of the water line is at least 18 inches above the top of the sanitary sewer line. Where water lines cross over sewer lines, install the water line so that the bottom of the water line is at least 18 inches above the top of the sewer line. When water, or sewer, location cannot be varied to provide separating distance, construct water line with mechanical joint pipe for a distance of 10 feet either side of sewer. One full length of water line is to be centered over sewer so that both joints will be as far from the sewer as possible.

3. Where it is not possible to obtain horizontal or vertical separation specified above, construct both water line and sewer line of mechanical joint, cement lined ductile iron pipe. Pressure test both pipes at 200 psi in accordance with AWWA C600.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

A. Ductile Iron Pipe: AWWA C151, Class 54, cement lined in accordance with AWWA C104, 18 foot nominal laying length, push on joints with SBR gaskets in accordance with AWWA C111.

B. Fittings (4”-12”): Compact ductile iron fittings in accordance with AWWA C153, cement lined in accordance with AWWA C104, mechanical joints with SBR gaskets, Corten nuts and bolts and ductile iron retainer glands, where required.

C. Retainer Glands: Ductile iron conforming to ASTM A536, 250 psi minimum working pressure, 2:1 minimum safety factor, Corten nuts and bolts, MEGALUG as manufactured by EBBA iron, Inc.

D. Tapping Sleeve: Fabricated carbon steel with fusion bonded epoxy coating, 200 psi minimum working pressure, SBR gaskets and sealing material, stainless steel bolting materials, provide with NPT test port and plug.

2.02 METAL SEATED GATE VALVES AND TAPPING VALVES

A. Valve: Conform to AWWA C500, mechanical joints ends, ductile iron retainer glands, SBR gaskets, Corten mechanical joint bolts and nuts, non-rising stem, 2” nut operator, 200 psi working pressure, type 304 stainless steel bonnet and O-ring stem seal bolting hardware. All valves shall open to the RIGHT.

B. Valve Box: 5-1/4 inch diameter, cast iron, flared base, slip type, flange top, tapered cover with long skirt and two pick holes, coal tar epoxy coated. Cover to have water identification markings.

C. Valve Extension Stem (if required): Provide self-centering steel valve extension stem with 2" nut operator, coal tar epoxy coated. Top of extension stem to be 1 foot below finished grade.

2.03 BEDDING MATERIAL

A. Sand: Use sand or sandy soil conforming to the requirements of Article M.08.08-21, DOT Specifications.

PART 3 – EXECUTION

3.01 GENERAL

A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Hand trim excavations to required elevations. Correct over excavation as specified in Section 02 21 00 – Earthwork.

B. Remove large stones or other hard matter, which could damage pipe or impede consistent backfilling or compaction.

C. Clean pipe and fitting interiors prior to lowering into trench. Keep clean during laying operations.

3.03 BEDDING

A. Excavate pipe trench in accordance with Section 02 21 00 – Earthwork for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Place and compact bedding material at trench bottom, level materials in continuous layer.

3.04 INSTALLATION

A. General

1. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe.

2. Install pipe, fittings and accessories in accordance with AWWA C600 and manufacturer's instructions. Seal joints watertight.

3. Place all pipe to grades and alignment shown on the Drawings.

4. Provide all equipment for lowering pipe safely into the trenches.

5. Lay pipe by proceeding upgrade with the spigot ends of bell-and-spigot pipe pointing in the direction of flow.

B. When the Engineer has accepted conditions at the bottom of the trench, place and compact the bedding of sand. Provide a bedding surface to support the barrel of the pipe throughout its entire length. Accurately shape the bedding to conform to the lower quarter of the pipe. Make depressions in the bedding for making pipe joints.

C. Make watertight pipe joints. Use gaskets as specified for each kind of pipe. Do the jointing in accordance with the pipe manufacturer's instructions and as follows:

1. Clean gaskets and mating surfaces of pipes. Use lubricant on gaskets and pipes if required by pipe manufacturer. Align pipe to be installed with previously installed pipe, and, with gasket in place, put joint together. After pipes are put together, inspect joint to verify that gasket is properly positioned and that joint has been properly made and is tight. If, while making the joint, the gasket becomes loose or displaced, remove the pipe and remake the joint to the acceptance of the Engineer.

2. Pipe to be installed "in the dry". Do not use pipe for trench drainage. Keep trench dry to prevent pipe floatation.

3. Cap ends of pipe when work is not in progress.

4. All mechanical joint fittings, bends, etc. shall be restrained a minimum of three (3) pipe lengths on either side of the fitting per Utilities Division standards.

3.05 INSTALLATION OF GATE VALVES

A. Install valves at locations indicated on the Drawings.

B. Provide a firm foundation and side support by tamping bedding material under and at the sides of the valves. Install valves with valve stems vertical.

C. Install valve boxes over valves such that vertical stems of valves are coincident with centerlines of valve boxes. Set boxes firmly in place by tamping bedding material under and at the sides of the boxes. Support valve boxes during backfilling; maintain vertical alignment. Install so that top of valve box is flush with final grade.

D. Install valve stem extensions of correct lengths on valves.

3.06 CONCRETE CRADLES, CONCRETE ENCASEMENTS AND CONCRETE THRUST BLOCKS

A. Construct concrete cradles, concrete encasements and concrete thrust blocks for additional support or protection of pipe at locations indicated on the Drawings or as directed by the Engineer.

3.07 COVER AND BACKFILL FOR PIPES

A. Protect finished installation from damage.

B. Place and compact sand blanket to one (1') foot above pipe so that all the space in the trench on each side of the pipe is entirely filled and well compacted.

C. Place warning tape over pipe as shown on the drawings. Tape shall clearly indicate "Buried Water Line" and be composed of a metallic material so as to be detectable by magnetic underground location indicators.

D. Place and compact suitable backfill material over sand blanket. Backfill in accordance with the requirements specified under Section 02 21 00 – Earthwork.

3.08 PRESSURE TESTING AND DISINFECTION

A. The Contractor shall perform all testing and disinfecting required, at no additional cost to the Owner. All testing shall conform to NFPA 24 "Standard for Installation of Private Fire Service Mains and Their Appurtenances" Latest Addition) and FM Global Data Sheet 3-10.

B. Arrange for local water authority to witness this work.

C. After installation of each waterline section, pipelines shall be tested for water tightness in accordance with AWWA C600. For these tests, the Contractor shall furnish suitable testing plugs or caps, all necessary pressure pumps, pipe connections, gages, or other equipment, all labor, and all water required.

D. Conduct leakage test at a pressure of 200 psi unless otherwise specified and maintain this pressure for 2 hours.

E. Before being placed in service, the completed water distribution system shall be disinfected in accordance with AWWA 651, "Standard Procedure for Disinfecting Water Mains." The Engineer shall approve the specific procedure before doing the work.

F. Water used to disinfect the water distribution system shall be chlorine neutralized as it is discharged from the system.

G. Perform bacterial and water quality testing to demonstrate compliance with applicable water quality standards. Sampling to be accomplished through sampling taps. Use of hydrants for sampling is prohibited.

H. Disinfect, flush and test water distribution system, repeatedly as required at Contractor's expense, to comply with applicable water quality standards.

I. All flushing shall be conducted at a minimum flow rate of 880 gpm. Flowing 2" drains is not an acceptable method of flushing lead-ins.

J. FM Global Form 85B, *Contractor's Material & Test Certificate for Underground Piping* should be completed and submitted to FM Global for review.

END OF SECTION

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PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Construction of sanitary sewers, manholes and related work, complete in place, as shown on the Drawings and as specified. Leakage testing of sanitary sewers and manholes will also be required.

1.02 SUBMITTALS

A. Submit Product Data

1. Manufacturers' descriptive literature for all items proposed to be furnished and installed under this Section, including Material Safety Data Sheets (MSDS) on all PVC adhesives and primers.

2. Manufacturer's specifications and other data required to demonstrate compliance with the specified requirements.

3. Verification of installer's qualifications.

1.03 DELIVERY, STORAGE AND HANDLING

A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.

B. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Engineer.

C. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no additional cost to the Owner.

1.04 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

A. Polyvinyl Chloride Pipe

1. Pipe: ASTM D3034, SDR 35 (Sizes: 4-15 in.)

2. Joints: Bell and spigot with O-ring gasket compressed between the bell and the spigot.

3. Gasket: Rubber gasket conforming to the requirements of AASHTO M198 or elastomeric gasket conforming to the requirements of ASTM D3212.

B. Provide fittings or couplings for joining pipes of different materials or provide concrete for fabricating a concrete collar where pipes of different materials are joined.

2.02 MANHOLE MATERIALS

A. Precast Reinforced Concrete Manhole Sections: Bases, manhole entrance slabs, riser sections, and conical sections shall conform to dimensions as shown on the Drawings and to the requirements of ASTM C478. All joints between sections shall be tongue and groove joints with recesses for rubber O-ring gaskets.

B. Rubber O-ring gaskets for joints shall conform to the requirements for rubber gaskets as specified under 5.9 Rubber Gaskets, ASTM C361.

C. Manhole Steps: Copolymer Polypropylene Plastic Manhole steps with serrated safety tread. Do not install steps by drilling and mortaring in place after casting of manhole sections.

D. Holes shall be preformed in the walls of base sections to accept sewer pipe. Flexible sleeves shall be cast into the preformed holes, as shown on the Drawings. The sleeves shall be made to fit and to be clamped around the pipe with stainless steel bands.

E. Alternatively, sleeves with internal-expanding stainless steel clamps may be used to install sleeves in preformed pipe holes.

F. Grout shall conform to Subarticle M.03.01-12 of the DOT Specifications.

G. Lubricant for use on joints and for use on O-ring rubber gaskets shall be an accepted vegetable soap compound.

H. Mortar shall conform to Article M.11.04 of the DOT Specifications.

I. Concrete grading rings, if used, shall conform to the requirements of ASTM C139.

J. Bricks used for adjusting frames to grade shall conform to the requirements of AASHTO M91, Grade MS. Bricks used for constructing inverts shall conform to the requirements of AASHTO M91, Grade SM.

K. Manhole frames and covers shall be standard models as shown on the Drawings. Material shall be cast iron conforming to the requirements of AASHTO M105, Class 25. Covers shall bear uniformly on their supports.

L. Dampproofing material and primer shall conform to the requirements of Article M.12.05 of the DOT Specifications.

2.03 BEDDING, COVER AND BACKFILL MATERIALS

A. Crushed stone for bedding shall be sound, tough and durable; it shall be free from soft, thin elongated, or laminated pieces and vegetable or other deleterious substances. Grading Article M.01.01, DOT Specifications. Size: As indicated on the Drawings.

B. Sand Blanket for Cover: Use sand or sandy soil conforming to the requirements of Article M.08.08-21 of the DOT Specifications.

C. Geotextile Filter Cloth: Section 31 23 33 – Trenching and Backfilling.

D. Suitable Backfill Material: Section 31 23 33 – Trenching and Backfilling

PART 3 – EXECUTION

3.01 GENERAL

A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 CONNECTIONS

A. Where a new pipe is to be connected into an existing manhole, the Contractor shall carefully cut into the existing manhole to obtain the minimum diameter hole required to construct the sewer to the line and grade indicated on the plans. The use of blunt instruments or excessive force will not be permitted.

B. The hole around the pipe shall be carefully sealed with non-shrink grout to obtain a watertight connection. A suitable invert channel, compatible with the existing formed invert, shall then be formed in the bottom of the existing manhole to the satisfaction of the Engineer.

3.03 CLEANING PIPELINES, MANHOLES AND APPURTENANCES

A. Upon completion of construction, all dirt and other foreign material shall be removed from pipelines and manholes. No materials shall be left to impede sewage flows.

3.04 TESTING AND INSPECTING

A. General: Provide all equipment and personnel necessary, and make all tests required to demonstrate that the work of this Section has been completed in strict accordance with the design and the specified requirements.

B. Closing-in uninspected work: Do not cause or allow any of the work of this Section to be covered up or enclosed until after it has been completely tested, inspected, and accepted by the Architect.

C. Make air leakage test on sanitary sewer pipelines and hydrostatic leakage test on manholes as indicated below.

3.05 AIR LEAKAGE TEST FOR SANITARY SEWERS

A. This test may not be used when the groundwater level is more than 9.25 feet above the invert of the pipe.

B. At the time of the air leakage test, the Contractor shall determine the groundwater elevation from observation wells, excavations, or by other means acceptable to the Architect.

C. The leakage test using low-pressure air shall be made on each manhole-to-manhole section of pipeline after placement of the backfill.

D. The Contractor shall do all the work and shall provide all the equipment necessary for the performance of the leakage test. The Contractor shall use equipment specifically designed and manufactured for the purpose of testing sewer pipelines using low-pressure air.

E. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be tested. Pneumatic plugs shall resist internal test pressures without requiring external bracing or blocking.

F. All air used shall pass through a single control panel. The air control equipment shall include a shut-off valve, a pressure regulating valve, a pressure reduction valve, and a monitoring pressure gage. The pressure reduction valve shall be set so that the internal air pressure in the pipeline cannot exceed 8 psig.

G. An individual pressure-sensing line shall be provided from the sealed pipeline to the monitoring pressure gage. An entirely separate line shall be provided for introducing the air into the sealed pipeline.

H. The monitoring pressure gage shall have a range from 0 to 10 psig. The gage shall have minimum divisions of 0.1 psi and an accuracy of 0.1 psi.

I. Low-pressure air shall be introduced into the sealed line until the internal air pressure reaches a pressure that is 4 psig. greater than the maximum pressure exerted by groundwater that may be above the invert of the pipe at the time of the test. However, the internal air pressure in the sealed line shall not be allowed to exceed 8 psig. (When the maximum pressure exerted by the groundwater is greater than 4 psig. or 9.25 feet of water, the Contractor shall conduct only an infiltration test as prescribed by the Architect.

J. At least two minutes shall be allowed for the air pressure to stabilize in the section under test. After the stabilization period, the shut-off valve shall be closed and the low-pressure air supply hose shall be quickly disconnected from the control panel. The time required in minutes for the pressure in the section under test to decrease from 3.5 to 2.5 psig. (greater than the maximum pressure exerted by groundwater that may be above the invert of the pipe) shall not be less than that shown in the following table:

Pipe Diameter in Inches	Minutes
4	2.0
6	3.0
8	4.0
10	5.0
12	5.5
15	7.5
18	8.5
21	10.0
24	11.5

K. When the sewer section being tested contains more than one size of pipe, the minimum allowable time shall be based on the largest diameter pipe in the section, and shall be the time shown in the table reduced by 0.5 minutes.

L. Repair, Replacement: Should any section of the sewer fail to meet the above requirements , the Contractor shall locate, repair, or replace defective joints and work at no additional expense to the Owner. Also, at no additional expense to the Owner, he shall repeat the test. This repair/replace/retests procedure shall be repeated until the sewer section meets the above requirements.

3.06 LEAKAGE TEST FOR MANHOLES

A. When the construction of manholes and installation and sealing of entering-and-leaving sewer pipes have been completed, leakage tests shall be conducted on the manholes. All tests shall be observed by the Architect.

B. Infiltration Test

1. If the groundwater table should be above the highest joint in the manhole and if the Architect does agree that infiltration test will be satisfactory, an infiltration test shall be used to evaluate the watertightness of the manhole. If the Architect does determine that there is no leakage into the manhole and does approve the manhole as being watertight, no further testing will be required. However, if the Architect is not satisfied that the manhole is watertight, the Contractor shall lower the water table and carry out exfiltration test as described below.

C. Exfiltration Test

1. The Contractor may backfill around the manhole before or after the following leakage test. The Contractor shall hereby be advised that it may be to his benefit to backfill following the leakage testing. If the Contractor should backfill before testing and if unacceptable leakage should occur, the Contractor will be required to re-excavate as necessary to correct the leakage and no extra payment will be made for this work. In addition, if the Contractor should backfill prior to the leakage test, he shall take any steps necessary to assure the Architect that the water table is below the bottom of the manhole throughout the test. Gravity sewer pipes entering and leaving manhole shall be temporarily plugged.

2. Manholes shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation by the Architect indicates no visible leakage, that is, no water visibly moving down the outside surface of the manhole, the manhole will have satisfactorily passed the test. If the manhole has visible leakage, as determined by the Architect, or if the manhole excavation has been backfilled, the test shall be continued or conducted as follows. The Contractor may allow water to set in manholes for a period of time to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and the test time of at least eight hours begun. At the end of the test time, the amount of water required to refill the manhole to the top of the cone shall be determined. A calculation shall be made to determine the 24-hour leakage rate per foot of manhole depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the test fails this requirement, but the leakage does not exceed three gallons per vertical foot per 24-hour period, repairs shall be made as approved or directed by the Architect to bring the leakage within the allowable rate of one gallon per foot per 24-hour period. If the leakage exceeds three gallons per vertical foot per 24-hour period, the manhole will be rejected. The Contractor shall then uncover the manhole, as necessary, and shall disassemble and reconstruct or replace it, as

directed by the Architect. The manhole shall then be retested. This procedure shall be repeated until manholes pass leakage test.

END OF SECTION

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PART 1 – GENERAL

1.01 DESCRIPTION

A. Work Included: Storm drain pipes, catch basins, manholes and related work, complete in place, as shown on the Drawings and as specified.

1.02 SUBMITTALS

A. Product Data:

1. Manufacturers' descriptive literature for all items proposed to be furnished and installed under this Section, including Material Safety Data Sheets (MSDS) on all PVC adhesives and primers.

2. Manufacturer's specifications and other data required to demonstrate compliance with the specified requirements.

3. Manufacturers' recommended installation procedures which, when accepted by the Owner, shall become the basis for inspecting and accepting or rejecting actual installation procedures used on this Work.

4. Verification of installer’s qualifications.

1.03 DELIVERY, STORAGE AND HANDLING

A. Protection: Use all means necessary to protect the materials of this Section before, during, and after installation, to protect the work and materials of all other trades, and to protect all objects designated to remain.

B. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as accepted by the Architect.

C. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Architect and at no additional cost to the Owner.

1.04 REFERENCES

A. Wherever reference is made to the DOT Specifications, it shall mean the Connecticut Department of Transportation Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (2004) as modified by Supplemental Specifications issued by the Connecticut Department of Transportation.

PART 2 – PRODUCTS

2.01 PIPE MATERIALS

A. Polyvinyl Chloride Pipe

1. Pipe: ASTM D3034, SDR 35 (Sizes: 4-15 in.)

2. Joints: Bell and spigot with O-ring gasket compressed between the bell and the spigot.

3. Gasket: Rubber gasket conforming to the requirements of AASHTO M198 or elastomeric gasket conforming to the requirements of ASTM D3212.

4. For Perforated pipe, make perforations 5/8-in. diameter on 5-in. centers, 120 degrees apart.

B. Reinforced Concrete Pipe

1. Pipe: Article M.08.01-6, DOT Specifications.

2. Gasket: Article M.08.01-20, DOT Specifications.

C. High Density Polyethylene Pipe

1. Pipe: All high-density polyethylene pipe shall have corrugated exterior and smooth interior and shall meet the following:

Sizes 3" to 10"	AASHTO M252, ASTM D3350 324420C
Sizes 12" to 38"	AASHTO M294, ASTM D3350 335420C

2. Coupling: Water Tight: Couplings designated on the drawings as watertight shall be gasketed, bell and spigot in accordance with the respective AASHTO specification. The bell shall be an integral part of the pipe for sizes up to and including 36" and shall provide a minimum pull apart strength of 400 pounds. Joints shall be accepted as water tight after passing a field air test after installation to ensure a leakage rate not to exceed 200 GPD/in = dia/mile or, in lieu of a field test, shall be accepted as water tight based on the manufacturer's certification that the leakage rate does not exceed 200 GPD/in-dia/mile based on laboratory testing.

2.02 CATCH BASINS, DRAINS, AND MANHOLES

A. Materials shall conform to the requirements of Article M.08.02 of the DOT Specifications.

B. Protective compound material: Article M.03.01-11 of the DOT Specifications.

C. Mortar: Article M.11.04 of the DOT Specifications.

D. Pervious material: Article M.02.05 of the DOT Specifications.

E. Galvanize steel frames and grates in accordance with the requirements of Article M.06.03, DOT Specifications. Do not galvanize cast iron frames and grates.

F. Trench Drains: ACO Drain KlassikDrain KS100 polymer concrete V-profile channel system with stainless steel edge rails. Grate to be Type 447Q/448Q longitudinal stainless steel grate

G. Deck Drains: Heavy duty floor drains with 12 inch round adjustable tops as manufactured by J.R. Smith Mfg. Co. Figure 2345C, caulk outlet with nickel bronze top.

2.03 BEDDING, BASE, COVER AND BACKFILL MATERIALS

A. Crushed stone for bedding shall be sound, tough and durable; it shall be free from soft, thin elongated, or laminated pieces and vegetable or other deleterious substances. Grading Article M.01.01, DOT Specifications. Size: As indicated on the Drawings.

B. Suitable Backfill Material: Section 31 23 33 – Trenching and Backfilling.

PART 3 – EXECUTION

3.01 GENERAL

A. Examine the areas and condition under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.02 EXCAVATION

A. Make excavations for catch basins, infiltration basins, yard drains, manholes, pipes and other drainage items in accordance with the provisions of Section 31 23 00 – Site Earthwork.

B. Protect bottoms of excavations from frost. Do not place bedding, structures, pipes, or fill materials on frozen ground.

C. Provide dewatering as specified under Section 02 21 00 – Earthwork. Keep excavations dry.

3.03 LAYING PIPE; JOINTING PIPE

A. General

1. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe.

2. Place all pipe to grades and alignment shown on the Drawings.

3. Provide all equipment for lowering pipe safely into the trenches.

4. Lay pipe by proceeding upgrade with the spigot ends of bell-and-spigot pipe, and the tongue ends of tongue-and-groove pipe pointing in the direction of flow.

B. When the Owner has accepted conditions at the bottom of the trench, place and compact the bedding of crushed stone. Provide a bedding surface to support the barrel of the pipe throughout its entire length. Accurately shape the bedding to conform to the lower quarter of the pipe. Make depressions in the bedding for making pipe joints.

C. Make watertight pipe joints. Use gaskets as specified for each kind of pipe. Do the jointing in accordance with the pipe manufacturer's instructions and as follows:

1. Clean gaskets and mating surfaces of pipes. Use lubricant on gaskets and pipes if required by pipe manufacturer. Align pipe to be installed with previously installed pipe, and, with gasket in place, put joint together. After pipes are put together, inspect joint to verify that gasket is properly positioned and that joint has been properly made and is tight. If, while making the joint, the gasket becomes loose or displaced, remove the pipe and remake the joint to the acceptance of the Architect.

D. Fill depressions under joints with granular fill bedding material and compact the material thoroughly.

E. Joining pipe of different materials: Provide fittings or couplings made for the pipe materials joining, or provide a concrete collar.

F. Place and compact bedding material (granular fill or in the case of underdrains, crushed stone) around both sides of pipe and over the top of the pipe as shown on the Drawings.

G. Place warning tape over pipe as shown on the drawings. Tape shall clearly indicate "Buried Storm Line" and be composed of a metallic material so as to be detectable by magnetic underground location indicators.

H. Place and compact suitable backfill material over bedding (cover) material as shown on the Drawings and in accordance with the requirements of Section 02 21 00 – Earthwork.

3.04 CONSTRUCTION OF CATCH BASINS, YARD DRAINS AND MANHOLES

A. When conditions at the bottom of the excavation are satisfactory to the Owner, place and compact the granular fill base. Bring the top of the granular base to the proper grade. Make granular base flat to uniformly support catch basin, yard drain, or manhole.

B. Construct catch basins, manholes, etc. and join pipes to structures in accordance with requirements of Article 5.07.03 of the DOT Specifications. Those requirements include:

1. Lay masonry units and metal frames in full mortar beds. In addition to the requirements of Article 5.07.03, apply a field coat of SS-1 emulsion to metal frames, grates and covers immediately before installation.

2. Plan to backfill with pervious material to extent indicated; provide a drainage opening in each wall immediately above the bottom of the pervious material, as indicated.

3. If cast-in-place concrete is used for tops, use bar reinforcement and apply protective compound material as indicated. Comply with other applicable requirements of Article 5.07.03.

C. When structures are constructed in sandy soils, apply damp proofing to outside wall surfaces.

D. Coordinate the backfilling work using suitable backfill material where indicated and pervious backfill material where indicated. Conform to backfilling requirements of Section 02 21 00 – Earthwork.

3.07 PIPE CONNECTIONS TO EXISTING DRAINAGE STRUCTURES

A. When connecting a new pipe into an existing drainage structure, carefully cut into the structure to produce the smallest possible hole for the pipe. Do not use blunt instruments or excessive force in cutting the hole. Locate the hole so that, when connected, the pipeline will be at line and grade indicated on the Drawings.

B. Carefully seal around the pipe with an acceptable non-shrink grout to obtain a watertight connection.

3.08 BACKFILLING

A. Backfill and compact backfill material in accordance with the provisions of Section 02 21 00 – Earthwork.

B. Where accepted by the Owner, sheeting and portions of bracing used may be left in place. Do not leave untreated sheeting in place beneath structures or pavements.

3.09 RAISING MANHOLES AND CATCH BASINS

A. Within the project area, raise all existing manholes and catch basins to finished grade.

B. Precast Concrete Manholes and Catch Basins

1. Raise by adding additional precast riser sections or by adding courses of brick or block as indicated on the Drawings.

2. If the total depth of adjusting brick or block exceeds 12 inches, raise by using precast riser sections. With brick or block, final adjustment not to exceed 12 inches.

C. Brick or Block Manholes and Catch Basins

1. Raise manholes in kind.

2. If the total depth of the manhole or Catch Basin (top of frame to lowest invert) will be increased to more than eight feet, rebuild the manhole or catch basin using 12-inch thick brick or block.

D. Reset existing frames and covers except where the Drawings call for replacement.

END OF SECTION

PART 1 – GENERAL

1.1 DESCRIPTION

The work covered by this section consists of the construction of a structural underground stormwater oil and sediment separator The Contractor shall furnish all equipment, tools, labor and materials necessary to complete the work in accordance with the plans and specifications.

1.2 REFERENCE STANDARDS

ASTM D-4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks ASTM C 478: Standard Specification for Precast Reinforced Concrete Manhole Sections ASTM C 443: Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

1.3 SHOP DRAWINGS

1.3.1 Shop drawings consisting of catalog cuts or fabricator drawings showing the structure and frames, grates, or covers shall be submitted by the Contractor to the Engineer for approval.

1.3.2 Where an external bypass is required, the manufacturer must provide calculations and designs for all structures, piping and any other required material applicable to the proper functioning of the system, stamped by a Professional Engineer.

1.4 HANDLING AND STORAGE

Care shall be taken in loading, transporting, and unloading to prevent damage to materials during storage and handling

PART 2 – PRODUCTS

2.1 GENERAL

The separator shall be circular and constructed from pre-cast concrete circular riser and slab components. The internal fiberglass insert shall be bolted and sealed watertight inside the reinforced concrete component. The separator shall be capable to be used as a bend or junction structure within the stormwater drainage system.

2.2 PRECAST CONCRETE SECTIONS

All precast concrete components shall be designed and manufactured to a minimum live load of AASHTO HS-20 truck loading or greater based on local regulatory specifications.

2.3 JOINTS

The concrete joints shall be water-tight and meet the design criteria according to ASTM C-443. Mastic sealants or butyl tape are not an acceptable alternative.

2.4 FRAME AND COVER

The frame and cover shall include an indented top design with lettering of the unit's name cast into the cover to allow for easy identification in the field.

2.5 CONCRETE

All reinforced concrete components shall be manufactured according to local specifications and shall meet the requirements of ASTM C 478.

2.6 FIBERGLASS

The fiberglass portion of the water treatment device shall be constructed in accordance with the following standard: ASTM D-4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks.

2.7 INSPECTION

All precast concrete sections shall be inspected to ensure that dimensions, appearance and quality of the product meet local specifications and ASTM C 478

PART 3 – PERFORMANCE

3.1 GENERAL

The stormwater quality treatment device shall remove oil and sediment from stormwater.

3.3 TOTAL SUSPENDED SOLIDS

The treatment device shall be capable of removing 80 percent of the average annual total suspended solids (TSS) load without scouring previously captured pollutants.

Design methodologies shall provide calculations substantiating removal efficiencies and correlation to field monitoring results using both particle size and TSS removal efficiency.

All manufactures shall provide performance data that the stormwater quality treatment system does not scour previously captured pollutants based on the

particle size distribution specified in section 3.5. Performance data should be laboratory testing with an initial sediment load of 50 percent of the unit's sediment capacity at an operating rate of 125% or greater. Particle size distribution (PSD) for the initial sediment load shall conform to table 3.5.

3.4 FREE OIL

3.4.1 The separator must be capable of removing 95 percent of the floatable free oil.

3.4.2 The first 16 inches (405 mm) of hydrocarbon storage shall be lined with fiberglass to provide a double wall containment of the hydrocarbon materials.

3.5 PARTICLE SIZE

3.5.1 The separator must be capable of trapping fine sand, silt, clay and organic particles in addition to larger sand, gravel particles and small floatablesThe stormwater quality treatment device shall be sized to a specific particle size distribution that is clearly identified in both diameter and specific gravity. The example below is a Fine Particle Size that is a common PSD used in design of water quality devices to ensure proper design for capturing smaller particles and the high load of associated pollutants.

Table 3.5 – Particle Size Distribution

Amount	Diameter	Specific Gravity
20%	20 micron	1.3
20%	60 micron	1.8
20%	150 micron	2.2
20%	400 micron	2.65
20%	2000 micron	2.65

PART 4 – EXECUTION

4.1 INSTALLATION

The installation of the pre-cast concrete stormwater quality treatment device should conform to state highway, municipal or local specifications for the construction of manholes. Selected sections of a general specification that are applicable are summarized below.

4.2 EXCAVATION

4.2.1 Excavation for the installation of the stormwater quality treatment device should conform to state highway, municipal or local specifications.

4.2.2 The stormwater quality treatment device should not be installed on frozen ground. Excavation should allow for adequate compaction around the structure. If the bottom of the excavation provides an unsuitable foundation additional excavation may be required.

4.2.3 In areas with a high water table, continuous dewatering should be provided to ensure that the excavation is stable and free of water.

4.3 BACKFILLING

Backfill material should conform to state highway, municipal or local specifications. Backfill material should be placed in uniform layers not exceeding 12 inches (300 mm) in depth and compacted to state highway, municipal or local specifications.

4.4 WATER QUALITY DEVICE CONSTRUCTION SEQUENCE

4.4.1 The concrete water quality device is installed in sections in the following sequence:

- aggregate base
- base slab
- treatment chamber section(s)
- transition slab (if required)
- bypass section
- connect inlet and outlet pipes
- riser section and/or transition slab (if required)
- maintenance riser section(s) (if required)
- frame and access cover

4.4.2 The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with gasketed joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

4.4.3 Adjustment of the stormwater quality treatment device can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary. Once the stormwater quality treatment device has been constructed, any lift holes must be plugged with mortar.

4.5 DROP PIPE AND RISER PIPE

Once the upper chamber has been attached to the lower chamber, the inlet drop tee, and riser pipe must be attached. Pipe installation instructions and required materials shall be provided with the insert.

4.6 INLET AND OUTLET PIPES

Inlet and outlet pipes should be securely set into the upper chamber using non-shrink grout or approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight.

4.7 FRAME AND COVER OR FRAME AND GRATE INSTALLATION

The grade adjustment units should be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover should be set in a full bed of mortar at the elevation specified.

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Section 50 30 00
Hazardous Building Materials Inspection and Inventory

Limited Hazardous Building Materials Inspection

October 11, 2016
Norwalk Community College
188 Richards Avenue
Norwalk, Connecticut

Board of Regents for Higher Education

Hartford, Connecticut

December 2016

FUSS & O'NEILL
EnviroScience, LLC

56 Quarry Road
Trumbull, CT 06611

Project No.20070369.A9E

FUSS & O'NEILL
EnviroScience, LLC

December 8, 2016

Ms. Yolanda Hacia
Director of Construction, Finance, and Administration
Board of Regents for Higher Education
61 Woodland Street
Hartford, Connecticut
06105-2337

Re: Limited Hazardous Building Materials Inspection
Phase III Renovations and Additions Project
Norwalk Community College
188 Richards Avenue, Norwalk, Connecticut
Fuss & O'Neill EnviroScience Project No. 20070369.A9E

Dear Ms. Hacia:

Enclosed is the report for the limited hazardous building materials inspection conducted in response to proposed renovations to the student center and theatre located at Norwalk Community College in Norwalk, Connecticut. The work was conducted for Board of Regents for Higher Education (the "Client").

The services were performed on October 11, 2016 by Fuss & O'Neill EnviroScience, LLC licensed inspectors and included a limited asbestos inspection, lead-based paint determination, and an inventory of PCB-containing ballasts and mercury-containing lamps. The information summarized in this report is for the above-mentioned materials only. The work was performed in accordance with our written proposal dated March 1, 2016.

If you should have any questions regarding the contents of this report, please do not hesitate to contact me at (203) 374-3748, extension 3535. Thank you for this opportunity to have served your environmental needs.

Sincerely,

Eduardo Miguel Marques
Environmental Analyst

Enclosure

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FUSS & O'NEILL
EnviroScience, LLC

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Limited Hazardous Building Materials Inspection Report
Norwalk Community College
Board of Regents for Higher Education

FUSS & O'NEILL
EnviroScience, LLC

1 Introduction

On October 11, 2016, Fuss & O'Neill EnviroScience, LLC (EnviroScience) representatives Mr. Robert Hobbins and Ms. Sandra Guzman performed a limited hazardous building materials inspection in response to the proposed renovations to the student center and theatre at Norwalk Community College located at 188 Richards Avenue in Norwalk, Connecticut (the "Site"). The work was conducted for the Board of Regents for Higher Education (the "Client") in accordance with our written scope of services dated March 1, 2016 and is subject to the limitations included in *Appendix A*.

The inspection included the following:

- limited asbestos inspection;
- lead-based paint (LBP) determination; and
- inventory of PCB-containing ballasts and mercury-containing lamps.

This hazardous building materials inspection was performed in response to proposed renovations associated with the Phase III Renovations and Additions Project. The following locations at the Site were included in this inspection:

- East Campus PepsiCo Theatre; and
- West Campus Student Center.

Note: The targeted areas included in this inspection were based on demolition/renovation drawings A1.01S – A1.03S (Student Center) and A1.01T – A1.03T (Theatre) provided by Mitchell/Giurgola Architects, LLP. Only the areas to be impacted by the proposed renovations as detailed in the above referenced drawings were included in this inspection. Please refer to *Appendix B* for renovation drawings.

This inspection was limited to non-invasive and discrete sampling techniques. Specific areas that were not inspected include the following:

- Beneath window and door frames;
- Within mechanical equipment;
- Spaces above fixed ceilings, solid walls and between and beneath floors; and
- Concealed pipe chases.

We have excluded collection and analysis of building materials for polychlorinated biphenyls (PCBs). Sampling for PCBs is presently not mandated by the Environmental Protection Agency (EPA); however, significant liability risk for disposing of PCB-containing wastes exists. Recent knowledge of PCBs within these matrices has become more prevalent, especially with remediation contractors, waste haulers, and disposal facilities. Many property Owners have become subject to large changes in schedule, scope, and costs as a result of failure to identify this possible contaminant prior to renovation or demolition.

2 Limited Asbestos Inspection

A property Owner must ensure that a thorough ACM inspection is performed prior to possible disturbance of suspect ACM during renovation or demolition activities. This is a requirement of the EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) regulation located at Title 40 CFR, Part 61, Subpart M.

On October 11, 2016, Mr. Robert Hobbins and Ms. Sandra Guzman of EnviroScience conducted the inspection. Mr. Hobbins and Ms. Guzman are both State of Connecticut Department of Public Health (CTDPH)-licensed Asbestos Inspectors. Refer to *Appendix C* for the Asbestos Inspector licenses and accreditations.

2.1 Methodology

The inspection was conducted by visually inspecting for suspect ACM and touching each of the suspect materials. The suspect materials were categorized into three EPA NESHAP groups: friable and non-friable Category I and Category II type ACM.

- A Friable Material is defined as material that contains greater than 1 percent (> 1%) asbestos that when dry **can** be crumbled, pulverized, or reduced to powder by hand pressure.
- A Category I Non-Friable Material refers to material that contains > 1% asbestos (i.e., packings, gaskets, resilient floor coverings, and asphalt roofing products) that when dry **cannot** be crumbled, pulverized, or reduced to powder by hand pressure.
- A Category II Non-Friable Material refers to any non-friable material excluding Category I materials that contain > 1% asbestos that when dry **cannot** be crumbled, pulverized, or reduced to powder by hand pressure.

The suspect ACM were also categorized into their applications including Thermal System Insulation (TSI), Surfacing ACM (S), and Miscellaneous ACM (M). TSI includes those materials used to prevent heat loss/gain or water condensation on mechanical systems. Examples of TSI are pipe insulation, boiler insulation, duct insulation, and mudded pipe fitting insulations. Surfacing ACM includes those ACM that are applied by spray, trowel, or otherwise applied to an existing surface. Surfacing ACM is commonly used for fireproofing, decorative, and acoustical applications. Miscellaneous materials include those ACM not listed as thermal or surfacing, such as linoleum, vinyl asbestos flooring, ceiling tiles, caulkings, glues, construction adhesives, etc.

The EPA recommends collecting suspect ACM samples in a manner sufficient to determine asbestos content and to segregate each suspect type of homogenous (similar in color, texture, and date of application) materials. The EPA NESHAP regulation does not specifically identify a minimum number of samples to be collected for each homogeneous material, but the NESHAP regulation does recommend the use of sampling protocols included in Title 40 CFR, Part 763, Subpart E: Asbestos Hazard Emergency Response Act (AHERA).

The EPA AHERA regulation requires a specific number of samples be collected based on the type of material and quantity present. This regulation includes the following protocol:

1. Surfacing Materials (S) (i.e., plasters, spray-applied fireproofings, etc.) must be collected in a randomly distributed manner representing each homogenous area based on the overall quantity represented by the sampling as follows:

    a. Three (3) samples collected from each homogenous area that is less than or equal to 1,000 square feet.
    b. Five (5) samples collected from each homogenous area that is greater than 1,000 square feet but less than or equal to 5,000 square feet.
    c. Seven (7) samples collected from each homogenous area that is greater than 5,000 square feet.

2. Thermal System Insulation (TSI) (i.e., pipe insulations, tank insulations, etc.) must be collected in a randomly distributed manner representing each homogenous area. Three (3) samples must be collected from each material. Also, a minimum of one (1) sample of any patching materials applied to TSI presuming the patched area is less than 6 linear or square feet should be collected.

3. Miscellaneous materials (M) (i.e., floor tile, gaskets, construction mastics, etc.) should have a minimum of two (2) samples collected for each type of homogenous material. Sample collection was conducted in a manner sufficient to determine asbestos content of the homogenous material as determined by the inspector.

The inspectors collected samples of those suspect ACM anticipated to be disturbed by proposed renovation activities, and prepared proper chain-of-custody forms for transmission of the samples to EMSL Analytical Inc. for analysis. EMSL is a Connecticut-licensed and American Industrial Hygiene Association (AIHA)-accredited asbestos laboratory. The sample locations, material type, sample identification, and asbestos content are identified by bulk sample analysis in Table 1 attached hereto. Suspect ACM not listed in the table that may be identified at a later date at the Site, should be assumed to be ACM until sample collection and analysis indicate otherwise. Initial asbestos sample analysis was conducted using the EPA Interim Method for the Determination of Asbestos in Bulk Building Materials (EPA/600/R-93/116) via Polarized Light Microscopy with Dispersion Staining (PLM/DS).

If samples of suspect materials could not be collected or were inaccessible but observed elsewhere, these materials were assumed to contain asbestos and the inspectors approximated quantities. The exterior and roof systems were included in the scope of work for this inspection. A roofing contractor assisted EnviroScience in obtaining and repairing the roof during sample collection. Limited destructive investigations were performed at the Client's request. These areas included the following:

- foundation walls; and
- spaces behind the brick façade.

Subsurface investigations including, but not limited to, concrete foundations were not performed. Also, EnviroScience did not conduct subsurface investigations to identify suspect cementitious pipe throughout the subject property.

2.2 Building Description

The targeted areas within the West Campus Student Center building structure includes two stories comprised of classrooms, mailroom, bathrooms, kitchen, and dining hall. The structure was reportedly constructed in the 1960's and the areas inspected encompasses approximately 20,000 square feet (SF) of total floor area. The East Campus PepsiCo Theatre consists of a 298-chair seating area, stage, and upper level productions room. The structure was reportedly constructed in the 1990's and encompasses approximately 5,300 SF of total floor area.

2.3 Results

Utilizing the EPA protocol and criteria, the following materials were determined to be **ACM**:

West Campus Student Center:

- Pipe fitting insulation;
- Black floor mastic,
- Gray rough coat wall plaster,
- Mirror glue,
- Gray interior/exterior window glazing,
- Tan exterior window caulking,
- Gray exterior door caulking,
- Gray exterior wall expansion caulking,
- Gray exterior foundation caulking,
- Tan exterior caulking on metal fascia,
- Gray cementitious soffit paneling, and
- Perimeter and penetration layered roofing (includes built-up layers, pitch tar, flashings, and base sheets).

East Campus PepsiCo Theatre:

- Black roof drain caulking;
- Black roof paper debris (from adjacent roof), and
- Adjacent pitched roof cementitious roof shingles.

The following materials were determined to contain trace amounts of asbestos (< 1%):

East Campus PepsiCo Theatre:

- 3" Tan cove base;
- Interior/exterior black window caulk; and
- Grayslate panel/tile concrete set.

West Campus Student Center:

- Gray exterior window caulk; and
- Black roof penetration build-up.

Refer to *Table 1* for a complete list of ACM and non-ACM identified as part of this inspection. Refer to *Table 2* attached hereto for the ACM inventory. Refer to *Appendix D* for the asbestos laboratory report(s) and chain-of-custody forms. Refer to *Appendix E* for site photographs.

2.4 Discussion

The EPA, the Occupational Safety and Health Administration (OSHA), and the CTDPH, define a material that contains greater than one percent (> 1%) asbestos, utilizing PLM/DS, as being an ACM. Materials that are identified as "none detected" are specified as not containing asbestos. Suspect ACM not identified during this inspection should be presumed to contain asbestos until sample collection and laboratory analysis indicate otherwise.

Additionally, the EPA has suggested that materials that are non-friable organically bound materials (e.g., asphaltic-based materials, adhesives, etc.) are recommended for further confirmatory analysis utilizing Transmission Electron Microscopy (TEM). Forty nine of the collected samples were recommended to be analyzed by TEM. The results of TEM analysis are denoted in *Table 1*.

2.5 Conclusions and Recommendations

Based on visual observations, sample collection, and laboratory analysis, ACM are present at the Site.

Prior to disturbance, ACM that would likely be impacted by the proposed renovation/demolition activities must first be abated by a state-licensed Asbestos Abatement Contractor. This is a requirement of CTDPH and EPA NESHAP regulations governing asbestos abatement.

The non-friable roofing materials identified in *Table 2* have been de-regulated by the CTDPH. The identified non-friable roofing material may be removed by either a CTDPH-licensed Asbestos Abatement Contractor, or by a roofing contractor provided that they adhere to all OSHA training requirements and EPA NESHAP regulatory requirements. All asbestos waste must be properly sealed (leak/airtight containers) and disposed in a landfill approved to accept asbestos-containing asphaltic roofing waste. A CTDPH-licensed Asbestos Abatement Contractor is only required should the ACM be made friable and become a regulated ACM (RACM) by work activities. If the roofing material becomes RACM, then all applicable CTDPH regulations will apply.

Due to the inability to effectively separate some types of multi-layered ACMs (e.g., floor tile/mastic) from non-ACM, these materials are considered asbestos-contaminated and must be managed as ACM for the purposes of removal and disposal.

Suspect materials encountered during renovation/demolition that are not identified in this report as being non-ACM should be presumed to be ACM until sample collection and laboratory analysis indicate otherwise. Prior to renovation/demolition that may disturb hidden/inaccessible areas, we recommend conducting a supplemental asbestos inspection of these areas and spaces

Materials are present in and on the Site where concentrations of asbestos are less than 1% (< 1%). While the EPA and the CTDPH identify materials containing < 1% as non-asbestos containing materials, Occupational Safety and Health Administration (OSHA) worker protection regulations apply to materials containing any amount of asbestos.

EnviroScience recommends that if any ACMs are to remain in the building following renovation/demolition activities, the ACM should be managed in-place under a written Operations and Maintenance Program in accordance with Occupational Safety and Health Administration (OSHA) regulations.

This report is not intended to be utilized as a bidding document or as a project specification document. The report is designed to aid the building owner, architect, construction manager, general contractors, and asbestos abatement contractors in locating ACM.

3 Lead-Based Paint Determination

On October 11, 2016 Mr. Hobbins of EnviroScience performed a lead-based paint (LBP) determination associated with coated building components at the Site that may be disturbed during renovation/demolition activities. An X-ray fluorescence (XRF) analyzer was used to perform the LBP determination. The determination was conducted in accordance with generally-accepted industry standards for non-residential (i.e., not child-occupied) buildings.

3.1 Methodology

A Radiation Monitoring Device Model LPA-1, serial number 3241R, was utilized for the LBP determination. The instrument was checked for proper calibration prior to use as detailed by the manufacturer and the Performance Characteristic Sheet (PCS) developed for the instruments.

Worker protection is regulated by Occupational Safety and Health Administration (OSHA) regulations, as well as CTDPH regulations. These regulations involve air monitoring of workers to determine exposure levels when disturbing lead-containing paint. An LBP determination cannot determine a safe level of lead, but is intended to provide guidance for implementing industry standards for lead in paint at identified locations. Contractors may then better determine exposure of workers to airborne lead by understanding the different concentrations of LBP activities that disturb paint on representative surfaces.

The EPA Resource Conservation and Recovery Act (RCRA) as well as CTDEEP regulate disposal of lead-containing waste. Lead-containing materials that will be impacted during renovation or demolition activities, and result in waste for disposal must either be analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) analysis if lead is determined to be present in non-residential buildings, or be presumed as a hazardous waste. A TCLP sample is a representative sample of the intended waste stream. The results are compared to a threshold value of 5.0 milligrams per liter (mg/L); a result exceeding this value is considered hazardous lead waste. If the result is below the established level, the material is not considered hazardous and may be disposed as general construction debris.

A level of LBP exceeding 1.0 milligrams of lead per square centimeter (mg/cm^2) is considered toxic or dangerous for compliance with residential standards. For purpose of this LBP determination the level of 1.0 mg/cm^2 has been utilized as a threshold for areas where possible worker exposures may occur.

3.2 XRF Determination Results

The LBP determination indicated consistent painting trends associated with representative building components that may be impacted by renovation work. None of the building components tested were determined to contain levels of lead greater than 1.0 mg/cm^2.

Refer to *Appendix F* for the XRF lead-based paint determination field data sheets.

3.3 Discussion

OSHA published a Lead in Construction Standard (OSHA Lead Standard) Title 29 CFR, Part 1926.62 in May 1993. The OSHA Lead Standard has no set limit for the content of lead in paint below which the standards do not apply. The OSHA Lead Standards are task-based, and derived from airborne exposure and blood lead levels.

The results of this LBP determination are intended to provide guidance to contractors for occupational lead exposure controls. Building components coated with lead levels above industry standards may cause exposures to lead above OSHA standards during proposed demolition and renovation activities. The results of this determination are also intended to provide insight into waste disposal requirements, in accordance with EPA RCRA regulations. A TCLP sample to characterize the expected waste that may result from possible selective demolition and/or renovation work was not collected as part of this inspection.

3.4 Conclusion and Recommendations

Based on our LBP determination results, LBP is not present on coated building components located on the targeted areas of the student center or theatre buildings tested during this inspection.

Contractors must be made aware that OSHA has not established a level of lead in a material below which Title 29 CFR, Part 1926.62 does not apply. Contractors shall comply with exposure assessment criteria, interim worker protection, and other requirements of the regulation as necessary to protect workers during any renovation work that will impact lead paint.

Note that future work involving surface preparation of identified painted surface(s) must be performed in accordance with OSHA worker protection requirements, as well as EPA Renovation, Repair and Painting Rule (RRP).

4 PCB-Containing Fluorescent Light Ballasts and Mercury-Containing Lamps

4.1 PCB-Containing Fluorescent Ballasts

Fluorescent light ballasts manufactured prior to 1979 may contain capacitors that contain PCBs. Light ballasts installed as late as 1985 may also contain PCB capacitors. Fluorescent light ballasts that are not labeled as "No-PCBs" must be assumed to contain PCBs, unless proven otherwise by quantitative analysis. Capacitors in fluorescent light ballasts labeled as non-PCB-containing may contain diethylhexl phthalate (DEHP). DEHP was the primary substitute to replace PCBs for small capacitors in fluorescent light ballasts in use until 1991. DEHP is a toxic substance, a suspected carcinogen, and is listed under EPA RCRA and the Superfund law as a hazardous waste. Therefore, EPA Superfund liability exists for landfilling both PCB and DEHP-containing light ballasts. These listed materials are considered hazardous waste under EPA RCRA, and require special handling and disposal considerations.

On October 11, 2016 EnviroScience representative(s), Mr. Hobbins and Ms. Guzman performed a visual inspection of representative fluorescent light fixtures to identify possible PCB-containing light ballasts. The inspection involved visually inspecting labels on representative light ballasts to identify dates of manufacture and labels indicating "No PCBs". Ballasts manufactured after 1991 were not listed as PCB or DEHP-containing ballasts, and were not quantified for disposal.

The light ballasts without a label indicating "No PCBs" are presumed to be PCB-containing waste and must be segregated for proper removal, packaging, transport, and disposal as PCB-containing waste. Those light ballasts labeled as "No PCBs" indicating manufacture dates prior to 1991 are presumed to contain DEHP. DEHP-containing light ballasts must be segregated for proper removal, packaging, transport, and disposal as non-PCB hazardous waste. Note that disposal requirements for DEHP-containing ballasts are slightly varied, and disposal costs are slightly less than PCB-containing light ballasts.

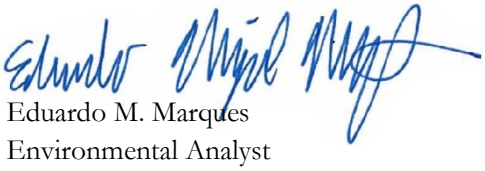
4.2 Mercury-Containing Equipment

Fluorescent lamps/tubes are presumed to contain mercury vapor, which is a hazardous substance to both human health and the environment. Thermostatic controls and electrical switch gear may contain a vial or bulb of mercury associated with the control. Mercury-containing equipment is regulated for proper disposal by the EPA RCRA hazardous waste regulations. According to the EPA, mercury lamps are characterized as a Universal Waste. Therefore, fluorescent lamps must be either recycled, or disposed as hazardous waste.

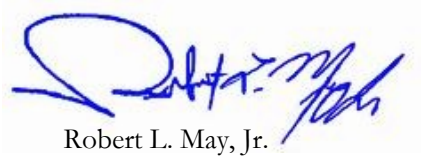
On October 11, 2016 EnviroScience representative(s), Mr. Hobbins and Ms. Guzman, performed an inventory of mercury lamps, thermometers, and mercury switches. These fixtures were inventoried in-place.

Report prepared by Environmental Analyst, Robert Hobbins.

Reviewed by:



Eduardo M. Marques
Environmental Analyst



Robert L. May, Jr.
President

Tables

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Table 1
Summary of Suspect Asbestos-Containing Materials

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
East Campus PepsiCo Theatre					
101116BH-01A	Backing Paper on Fiberglass Pipe Insulation	Non-ACM	Theater Projection above Drop Ceiling	ND	PLM
101116BH-01B	Backing Paper on Fiberglass Pipe Insulation	Non-ACM	Theater Projection above Drop Ceiling	ND	PLM
101116BH-02A	Gray Concrete Floor	Non-ACM	Theater by Left Entrance	ND	PLM
101116BH-02B	Gray Concrete Floor	Non-ACM	Theater by Stage under Wood Floor	ND	PLM
101116BH-03A	Yellow Carpet Glue	Non-ACM	Theater Audience Area	ND	PLM
101116BH-03B	Yellow Carpet Glue	Non-ACM	Theater Corridor by Left Door Stage Entrance	ND	PLM
101116BH-04A	Black 4" Cove Base	Non-ACM	Theater Audience Area	ND	PLM
101116BH-04B	Black 4" Cove Base	Non-ACM	Theater Audience Area	ND	PLM
101116BH-05A	White Cove Base Glue	Non-ACM	Theater Audience Area	ND / ND	PLM/TEM NOB
101116BH-05B	White Cove Base Glue	Non-ACM	Theater Audience Area	ND	PLM
101116BH-06A	Yellow Cove Base Glue	Non-ACM	Theater Stage	ND / ND	PLM/TEM NOB
101116BH-06B	Yellow Cove Base Glue	Non-ACM	Theater Stage	ND	PLM
101116BH-07A	Beige Gray Specks 12"x12" Floor Tiles	Non-ACM	Theater Projection Room	ND / ND	PLM/TEM NOB
101116BH-07B	Beige Gray Specks 12"x12" Floor Tiles	Non-ACM	Theater Projection Room Storage	ND	PLM
101116BH-08A	Black Floor Tiles Mastic	Non-ACM	Theater Projection Room	ND / ND	PLM/TEM NOB
101116BH-08B	Black Floor Tiles Mastic	Non-ACM	Theater Projection Room Storage	ND	PLM
101116BH-09A	Tan 3" Cove Base	Non-ACM	Theater Projection Room	ND/0.25% Chrysotile	PLM
101116BH-09B	Tan 3" Cove Base	Non-ACM	Theater Projection Room Storage	ND	PLM
101116BH-10A	Beige Cove Base Glue	Non-ACM	Theater Projection Room	ND / ND	PLM/TEM NOB
101116BH-10B	Beige Cove Base Glue	Non-ACM	Theater Projection Room Storage	ND	PLM
101116BH-11A	Gray Concrete Block	Non-ACM	Theater Audience Area Wall	ND	PLM
101116BH-11B	Gray Concrete Block	Non-ACM	Theater Audience Area Wall	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
East Campus PepsiCo Theatre					
101116BH-12A	Gray Concrete Block Grout	Non-ACM	Theater Audience Area Wall	ND	PLM
101116BH-12B	Gray Concrete Block Grout	Non-ACM	Theater Audience Area Wall	ND	PLM
101116BH-13A	White Concrete Wall Tiles	Non-ACM	Theater Audience Area	ND	PLM
101116BH-13B	White Concrete Wall Tiles	Non-ACM	Theater Projection Room	ND	PLM
101116BH-14A	Terracotta Brick	Non-ACM	Theater Audience Area Interior Wall	ND	PLM
101116BH-14B	Terracotta Brick	Non-ACM	Theater Stage Exterior Wall	ND	PLM
101116BH-15A	Gray Terracotta Brick Grout	Non-ACM	Theater Audience Area Interior Wall	ND	PLM
101116BH-15B	Gray Terracotta Brick Grout	Non-ACM	Theater Stage Exterior Wall	ND	PLM
101116BH-16A	White Sheetrock	Non-ACM	Theater Audience Area Ceiling to Projection Room	ND	PLM
101116BH-16B	White Sheetrock	Non-ACM	Theater Projection Room Wall	ND	PLM
101116BH-17A	White Sheetrock Joint Compound	Non-ACM	Theater Audience Area Ceiling to Projection Room	ND	PLM
101116BH-17B	White Sheetrock Joint Compound	Non-ACM	Theater Projection Room Wall	ND	PLM
101116BH-18A	Black 12"x12" Wall Tiles	Non-ACM	Theater Audience Right Entrance on Hand Rail	ND	PLM
101116BH-18B	Black 12"x12" Wall Tiles	Non-ACM	Theater Audience Right Entrance on Hand Rail	ND	PLM
101116BH-19A	Black Wall Tiles Grout	Non-ACM	Theater Audience Right Entrance on Hand Rail	ND	PLM
101116BH-19B	Black Wall Tiles Grout	Non-ACM	Theater Audience Right Entrance on Hand Rail	ND	PLM
101116BH-20A	Gray Acoustic Insulation Paneling	Non-ACM	Theater Audience Wall to Projection	ND	PLM
101116BH-20B	Gray Acoustic Insulation Paneling	Non-ACM	Theater Audience Wall to Projection	ND	PLM
101116BH-21A	Exterior Black Window Caulk	Non-ACM	Theater Projection Room Window	ND / ND	PLM/TEM NOB
101116BH-21B	Interior/Exterior Black Window Caulk	Non-ACM	Corridor Window to Theater Stage Door	<1% Chrysotile	PLM
101116BH-22A	Brown Interior Window Caulk	Non-ACM	Theater Projection Room Storage Window	ND / ND	PLM/TEM NOB
101116BH-22B	Brown Interior Window Caulk	Non-ACM	Theater Projection Room Storage Window	ND	PLM
101116BH-23A	Gray Interior Expansion Caulking	Non-ACM	Theater Concrete Wall Tile at Audience Area Painted White	ND / ND	PLM/TEM NOB

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
East Campus PepsiCo Theatre					
101116BH-23B	Gray Interior Expansion Caulking	Non-ACM	Theater Stage Concrete Block Wall Painted Black	ND	PLM
101116BH-24A	Gray Interior Door Caulking	Non-ACM	Theater Stage Left Double Door	ND / ND	PLM/TEM NOB
101116BH-24B	Gray Interior Door Caulking	Non-ACM	Theater Stage Right Double Door	ND	PLM
101116BH-25A	Brown Interior Door Caulking	Non-ACM	Theater Interior Single Door	ND / ND	PLM/TEM NOB
101116BH-25B	Brown Interior Door Caulking	Non-ACM	Theater Exterior Single Door No 15	ND	PLM
101116BH-26A	White 2'x6' Ceiling Tiles	Non-ACM	Theater Audience Right Entrance	ND	PLM
101116BH-26B	White 2'x6' Ceiling Tiles	Non-ACM	Theater Projection Room Storage	ND	PLM
101116BH-27A	White 2'x2' Ceiling Tiles	Non-ACM	Theater Projection Room Drop Ceiling	ND	PLM
101116BH-27B	White 2'x2' Ceiling Tiles	Non-ACM	Theater Projection Room Drop Ceiling	ND	PLM
101116BH-28A	White Laminate Counter Top	Non-ACM	Theater Projection Room	ND / ND	PLM/TEM NOB
101116BH-28B	White Laminate Counter Top	Non-ACM	Theater Projection Room	ND	PLM
101116BH-29A	Brown Exterior Expansion Joint	Non-ACM	Theater Exterior Side B Wall	ND / ND	PLM/TEM NOB
101116BH-29B	Brown Exterior Expansion Joint	Non-ACM	Theater Exterior Side C Wall	ND	PLM
101116BH-30A	Gray Foundation Wall	Non-ACM	Exterior of Theater Foundation Wall	ND	PLM
101116BH-30B	Gray Foundation Wall	Non-ACM	Exterior of Theater Foundation Wall	ND	PLM
101116BH-31A	Black Tar/Membrane	Non-ACM	Exterior of Theater behind 1st Course of Brick at Foundation	ND / ND	PLM/TEM NOB
101116BH-31B	Black Tar/Membrane	Non-ACM	Exterior of Theater behind 1st Course of Brick at Foundation	ND	PLM
101116BH-32A	Black Slate Panel/Tile	Non-ACM	Exterior of Theater Side D above Door 15	ND	PLM
101116BH-32B	Black Slate Panel/Tile	Non-ACM	Exterior of Theater Roof Side A	ND	PLM
101116BH-33A	Gray Slate Panel/Tile Concrete Set	Non-ACM	Exterior of Theater Side D above Door 15	ND	PLM
101116BH-33B	Gray Slate Panel/Tile Concrete Set	Non-ACM	Exterior of Theater Roof Side A	<1% Chrysotile	PLM
101116BH-34A	Gray Slate Panel Grout	Non-ACM	Exterior of Theater Side D above Door 15	ND	PLM
101116BH-34B	Gray Slate Panel Grout	Non-ACM	Exterior of Theater Roof Side A	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
East Campus PepsiCo Theatre					
101116BH-35A	Gray Slate Panel/Tile Caulking	Non-ACM	Exterior of Theater Side D above Door 15	ND / ND	PLM/TEM NOB
101116BH-35B	Gray Slate Panel/Tile Caulking	Non-ACM	Exterior of Theater Roof Side A	ND	PLM
101116BH-36A	Tan Composite Backing Panel	Non-ACM	Behind Theater Roof Black Slate/Tile Wall	ND	PLM
101116BH-36B	Tan Composite Backing Panel	Non-ACM	Behind Theater Roof Black Slate/Tile Wall	ND	PLM
101116BH-37A	White Window Caulking	Non-ACM	Theater Roof Fiberglass Window	ND / ND	PLM/TEM NOB
101116BH-37B	White Window Caulking	Non-ACM	Theater Roof Fiberglass Window	ND	PLM
101116BH-38A	**Cementitious Shingles**	**Cat 2 NF**	**Pitched Rood adjacent to Theater Roof**	**35% Chrysotile**	**PLM**
101116BH-38B	**Cementitious Shingles**	**Cat 2 NF**	**Pitched Rood adjacent to Theater Roof**	**NA/PS**	**PLM**
101116BH-39A	Black Top Membrane	Non-ACM	Theater Roof Field by Center	ND / ND	PLM/TEM NOB
101116BH-39B	Black Top Membrane	Non-ACM	Theater Roof by Side A	ND	PLM
101116BH-40A	Yellow Foam Roof Insulation	Non-ACM	Theater Roof Field by Center	ND	PLM
101116BH-40B	Yellow Foam Roof Insulation	Non-ACM	Theater Roof by Side A	ND	PLM
101116BH-41A	Black Membrane	Non-ACM	Theater Roof Edge	ND / ND	PLM/TEM NOB
101116BH-41B	Black Membrane	Non-ACM	Theater Roof Edge	ND	PLM
101116BH-42A	Yellow Membrane Glue	Non-ACM	Theater Roof Edge	ND / ND	PLM/TEM NOB
101116BH-42B	Yellow Membrane Glue	Non-ACM	Theater Roof Edge	ND	PLM
101116BH-43A	Layer 1 Black Rubber Membrane	Non-ACM	Theater Roof Penetration	ND / ND	PLM/TEM NOB
101116BH-43B	Layer 2 Black Rubber Membrane	Non-ACM	Theater Roof Penetration	ND	PLM
101116BH-44A	Yellow Rubber Membrane Glue	Non-ACM	Theater Roof Penetration	ND	PLM
101116BH-44B	Yellow Rubber Membrane Glue	Non-ACM	Theater Roof Penetration	ND	PLM
101116BH-45A	Black Tar	Non-ACM	Theater Roof Penetration underneath of 2nd Layer of Rubber	ND / ND	PLM/TEM NOB
101116BH-45B	Black Tar	Non-ACM	Theater Roof Penetration underneath of 2nd Layer of Rubber	ND	PLM
101116BH-46A	**Gray/Black Drain Caulk**	**Cat 2 NF**	**Theater Roof Drain**	**5% Chrysotile**	**PLM**

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
East Campus PepsiCo Theatre					
101116BH-46B	**Gray/Black Drain Caulk**	**Cat 2 NF**	**Theater Roof Drain**	**NA/PS**	**PLM**
101116BH-47A	Black Pitch Pocket Tar	Non-ACM	Theater Roof Pitch Pocket	ND / ND	PLM/TEM NOB
101116BH-47B	Black Pitch Pocket Tar	Non-ACM	Theater Roof Pitch Pocket	ND	PLM
101116BH-49A	**Black Roof Paper**	**Cat 1 NF**	**Theater Roof Loose Material**	**2% Chrysotile**	**PLM**
101116BH-49B	**Black Roof Paper**	**Cat 1 NF**	**Theater Roof Loose Material**	**NA/PS**	**PLM**
West Campus Student Center					
101116BH-01A	**Pipe Fitting Insulation**	**Friable ACM**	**SC Corridor by Cafeteria above Drop Ceiling**	**6% Chrysotile**	**PLM**
101116BH-01B	**Pipe Fitting Insulation**	**Friable ACM**	**SC Kitchen AC Unit 1**	**NA/PS**	**PLM**
101116BH-01C	**Pipe Fitting Insulation**	**Friable ACM**	**SC Kitchen AC Unit 2**	**NA/PS**	**PLM**
101116BH-02A	Backing Paper on Fiberglass Pipe Insulation	Non-ACM	SC Kitchen Storage 1 Room	ND	PLM
101116BH-02B	Backing Paper on Fiberglass Pipe Insulation	Non-ACM	SC Kitchen Storage 1 Room	ND	PLM
101116BH-03A	Yellow Carpet Glue	Non-ACM	SC Kitchen Office	ND / ND	PLM/TEM NOB
101116BH-03B	Yellow Carpet Glue	Non-ACM	SC Room W229	ND	PLM
101116BH-04A	Green Carpet Glue	Non-ACM	SC Café	ND / ND	PLM/TEM NOB
101116BH-04B	Green Carpet Glue	Non-ACM	SC Café	ND	PLM
101116BH-05A	12"x12" White Tan Streaks Floor Tiles	Non-ACM	SC Mail Room Floor	ND / ND	PLM/TEM NOB
101116BH-05B	12"x12" White Tan Streaks Floor Tiles	Non-ACM	SC Room W229 underneath Carpet	ND	PLM
101116BH-06A	12"x12" Red Floor Tiles	Non-ACM	SC Cafe underneath Carpet	ND / ND	PLM/TEM NOB
101116BH-06B	12"x12" Red Floor Tiles	Non-ACM	SC Cafe underneath Carpet	ND	PLM
101116BH-07A	12"x12" Green Floor Tiles	Non-ACM	SC Cafe Service Area	ND / ND	PLM/TEM NOB
101116BH-07B	12"x12" Green Floor Tiles	Non-ACM	SC Cafe Service Area	ND	PLM
101116BH-08A	Yellow Floor Tiles	Non-ACM	SC Cafe Service Area	ND / ND	PLM/TEM NOB
101116BH-08B	Yellow Floor Tiles	Non-ACM	SC Cafe Service Area	ND	PLM

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Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-09A	Black Floor Tiles Mastic	Non-ACM	SC Room W229SC	ND	PLM
101116BH-09B	**Black Floor Tiles Mastic**	**Cat 1 NF**	**SC Café**	**5% Chrysotile**	**PLM**
101116BH-09C	**Black Floor Tiles Mastic**	**Cat 1 NF**	**SC Corridor by Cafeteria**	**NA/PS**	**PLM**
101116BH-10A	Green 4" Cove Base	Non-ACM	SC Café	ND	PLM
101116BH-10B	Green 4" Cove Base	Non-ACM	SC Café	ND	PLM
101116BH-11A	Beige Cove Base Glue	Non-ACM	SC Café	ND / ND	PLM/TEM NOB
101116BH-11B	Beige Cove Base Glue	Non-ACM	SC Café	ND	PLM
101116BH-12A	Gray 4" Cove Base	Non-ACM	SC Corridor Outside Cafeteria	ND	PLM
101116BH-12B	Gray 4" Cove Base	Non-ACM	SC Corridor Outside Cafeteria	ND	PLM
101116BH-13A	Yellow Cove Base Glue	Non-ACM	SC Corridor Outside Cafeteria	ND / ND	PLM/TEM NOB
101116BH-13B	Yellow Cove Base Glue	Non-ACM	SC Corridor Outside Cafeteria	ND	PLM
101116BH-14A	Brown 1"x2" Ceramic Tiles	Non-ACM	SC 2nd Floor Women's Bathroom Floor	ND	PLM
101116BH-14B	Brown 1"x2" Ceramic Tiles	Non-ACM	SC Kitchen Floor Bathroom	ND	PLM
101116BH-15A	Gray Ceramic Grout	Non-ACM	SC 2nd Floor Women's Bathroom Floor	ND	PLM
101116BH-15B	Gray Ceramic Grout	Non-ACM	SC Kitchen Floor Bathroom	ND	PLM
101116BH-16A	Green 1"x2" Ceramic Tiles	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-16B	Green 1"x2" Ceramic Tiles	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-17A	Gray Ceramic Grout	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-17B	Gray Ceramic Grout	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-18A	Gray Ceramic Thinset	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-18B	Gray Ceramic Grout Thinset	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-19A	Brown 6"x6" Ceramic Floor Tiles	Non-ACM	SC Kitchen Floor	ND	PLM
101116BH-19B	Brown 6"x6" Ceramic Floor Tiles	Non-ACM	SC Kitchen Floor	ND	PLM

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Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-20A	Gray 6"x6" Ceramic Floor Tiles Grout	Non-ACM	SC Kitchen Floor	ND	PLM
101116BH-20B	Gray 6"x6" Ceramic Floor Tiles Grout	Non-ACM	SC Kitchen Floor	ND	PLM
101116BH-21A	Gray Ceramic Floor Tiles Thinset	Non-ACM	SC Kitchen Floor	ND	PLM
101116BH-21B	Gray Ceramic Floor Tiles Thinset	Non-ACM	SC Kitchen Floor	ND	PLM
101116BH-22A	Gray Glazed Block Wall Tiles	Non-ACM	SC Room W229	ND	PLM
101116BH-22B	Gray Glazed Block Wall Tiles	Non-ACM	SC Mail Room	ND	PLM
101116BH-23A	Gray Concrete Block	Non-ACM	SC 1st Floor Corridor by Mail Room	ND	PLM
101116BH-23B	Gray Concrete Block	Non-ACM	SC 2nd Floor Corridor by Room W229	ND	PLM
101116BH-24A	Gray Concrete Block Grout	Non-ACM	SC 1st Floor Corridor by Mail Room	ND	PLM
101116BH-24B	Gray Concrete Block Grout	Non-ACM	SC 2nd Floor Corridor by Room W229	ND	PLM
101116BH-25A	Brown 6"x6" Ceramic Wall Tiles	Non-ACM	SC Kitchen Sink	ND	PLM
101116BH-25B	Brown 6"x6" Ceramic Wall Tiles	Non-ACM	SC Kitchen Sink	ND	PLM
101116BH-26A	Gray Wall Ceramic Tiles Grout	Non-ACM	SC Kitchen Sink	ND	PLM
101116BH-26B	Gray Wall Ceramic Tiles Grout	Non-ACM	SC Kitchen Sink	ND	PLM
101116BH-27A	Blue 4" Ceramic Wall Tiles	Non-ACM	SC Kitchen Bathroom	ND	PLM
101116BH-27B	Blue 4" Ceramic Wall Tiles	Non-ACM	SC Women's Bathroom by Room W229	ND	PLM
101116BH-28A	Green 4" Ceramic Wall Tiles	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-28B	Green 4" Ceramic Wall Tiles	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-29A	White Ceramic Tiles Thinset	Non-ACM	SC Kitchen Bathroom	ND	PLM
101116BH-29B	White Ceramic Tiles Thinset	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-30A	White Ceramic Tiles Grout	Non-ACM	SC Kitchen Bathroom	ND	PLM
101116BH-30B	White Ceramic Tiles Grout	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229	ND	PLM
101116BH-31A	White Sheetrock	Non-ACM	SC Cafeteria	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-31B	White Sheetrock	Non-ACM	SC Room W229	ND	PLM
101116BH-32A	White Sheetrock Joint Compound	Non-ACM	SC Cafeteria	ND	PLM
101116BH-32B	White Sheetrock Joint Compound	Non-ACM	SC Cafeteria	ND	PLM
101116BH-33A	White Wall Panel	Non-ACM	SC Kitchen	ND	PLM
101116BH-33B	White Wall Panel	Non-ACM	SC Kitchen	ND	PLM
101116BH-34A	Yellow Wall Panel Glue	Non-ACM	SC Kitchen	ND	PLM
101116BH-34B	Yellow Wall Panel Glue	Non-ACM	SC Kitchen	ND	PLM
101116BH-35A	**Gray Rough Coat**	**Friable ACM**	**SC Kitchen Walking Cooler Wall behind Wall Panel**	**3% Chrysotile**	**PLM**
101116BH-35B	**Gray Rough Coat**	**Friable ACM**	**SC Kitchen Walking Cooler Wall behind Wall Panel**	**NA/PS**	**PLM**
101116BH-35C	**Gray Rough Coat**	**Friable ACM**	**SC Kitchen Walking Cooler Wall behind Wall Panel**	**NA/PS**	**PLM**
101116BH-36A	White Laminate Counter	Non-ACM	SC 2nd Floor Men's Bathroom	ND / ND	PLM/TEM NOB
101116BH-36B	White Laminate Counter	Non-ACM	SC Mail Room	ND	PLM
101116BH-37A	Yellow Laminate Counter Glue	Non-ACM	SC 2nd Floor Men's Bathroom	ND / Not Analyzed	PLM/TEM NOB
101116BH-37B	Yellow Laminate Counter Glue	Non-ACM	SC Mail Room	ND	PLM
101116BH-38A	White Plaster Skim Coat	Non-ACM	SC 1st Floor Kitchen Bathroom Ceiling	ND	PLM
101116BH-38B	White Plaster Skim Coat	Non-ACM	SC 1st Floor Kitchen Bathroom Ceiling	ND	PLM
101116BH-38C	White Plaster Skim Coat	Non-ACM	SC 1st Floor Kitchen Ceiling	ND	PLM
101116BH-38D	White Plaster Skim Coat	Non-ACM	SC 2nd Floor Women's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-38E	White Plaster Skim Coat	Non-ACM	SC 2nd Floor Women's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-38F	White Plaster Skim Coat	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-38G	White Plaster Skim Coat	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229 Ceiling	ND	PLM

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Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-39A	Light Gray Plaster Rough Coat	Non-ACM	SC 1st Floor Kitchen Bathroom Ceiling	ND	PLM
101116BH-39B	Light Gray Plaster Rough Coat	Non-ACM	SC 1st Floor Kitchen Bathroom Ceiling	ND	PLM
101116BH-39C	Light Gray Plaster Rough Coat	Non-ACM	SC 1st Floor Kitchen Ceiling	ND	PLM
101116BH-39D	Light Gray Plaster Rough Coat	Non-ACM	SC 2nd Floor Women's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-39E	Light Gray Plaster Rough Coat	Non-ACM	SC 2nd Floor Women's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-39F	Light Gray Plaster Rough Coat	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-39G	Light Gray Plaster Rough Coat	Non-ACM	SC 2nd Floor Men's Bathroom by Room W229 Ceiling	ND	PLM
101116BH-40A	White 1"x1" Ceiling Tiles	Non-ACM	SC 2nd Floor Room W229	ND	PLM
101116BH-40B	White 1"x1" Ceiling Tiles	Non-ACM	SC Mail Room	ND	PLM
101116BH-41A	White 2"x4" Ceiling Tiles	Non-ACM	SC 2nd Floor Corridor by Café	ND	PLM
101116BH-41B	White 2"x4" Ceiling Tiles	Non-ACM	SC 1st Floor Mail Room	ND	PLM
101116BH-42A	White 2"x6" Type I Ceiling Tiles	Non-ACM	SC Cafeteria	ND	PLM
101116BH-42B	White 2"x6" Type I Ceiling Tiles	Non-ACM	SC Cafeteria	ND	PLM
101116BH-43A	White 2"x6" Type II Ceiling Tiles	Non-ACM	SC Cafeteria	ND	PLM
101116BH-43B	White 2"x6" Type II Ceiling Tiles	Non-ACM	SC Cafeteria	ND	PLM
101116BH-44A	Brown Ceiling Tiles Glue Daubs	Non-ACM	SC Mail Room	ND / ND	PLM/TEM NOB
101116BH-44B	Brown Ceiling Tiles Glue Daubs	Non-ACM	SC Café	Not Analyzed	PLM
101116BH-45A	Light Yellow Ceiling Tiles Glue Daubs	Non-ACM	SC 2nd Floor Room W229	ND / ND	PLM/TEM NOB
101116BH-45B	Light Yellow Ceiling Tiles Glue Daubs	Non-ACM	SC 2nd Floor Room W229	ND	PLM
101116BH-46A	Dark Yellow Ceiling Tiles Glue Daubs	Non-ACM	SC 2nd Floor Room W229	ND / ND	PLM/TEM NOB
101116BH-46B	Dark Yellow Ceiling Tiles Glue Daubs	Non-ACM	SC 2nd Floor Room W229	ND	PLM
101116BH-47A	Black Window Sill	Non-ACM	SC Room W229	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-47B	Black Window Sill	Non-ACM	SC Café	ND	PLM
101116BH-48A	Gray Window Sill Grout	Non-ACM	SC Room W229	ND	PLM
101116BH-48B	Gray Window Sill Grout	Non-ACM	SC Café	ND	PLM
101116BH-49A	**Gray Interior/Exterior Window Glazing**	**Cat 2 NF**	**SC Café Window**	**3% Chrysotile**	**PLM**
101116BH-49B	**Gray Interior/Exterior Window Glazing**	**Cat 2 NF**	**SC Room W229**	**NA/PS**	**PLM**
101116BH-50A	White Window Glazing	Non-ACM	SC 2nd Floor Men's Bathroom Window	ND / ND	PLM/TEM NOB
101116BH-50B	White Window Glazing	Non-ACM	SC 2nd Floor Men's Bathroom Window	ND	PLM
101116BH-51A	Gray Exterior Window Caulking	Non-ACM	SC Café Exterior Side C Window System	<1%/ <0.1% Chrysotile	PLM/TEM NOB
101116BH-51B	Gray Exterior Window Caulking	Cat 2 NF	SC Mail Room Exterior Window System	<1%	PLM
101116BH-52A	**Tan Exterior Window Caulking**	**Cat 2 NF**	**SC Café Exterior Side C Window System**	**6% Chrysotile**	**PLM**
101116BH-52B	**Tan Exterior Window Caulking**	**Cat 2 NF**	**SC Mail Room Exterior Window System**	**NA/PS**	**PLM**
101116BH-53A	**Gray Bottom Exterior Window Caulking**	**Cat 2 NF**	**SC Cafe Exterior Window**	**8% Chrysotile**	**PLM**
101116BH-53B	**Gray Bottom Exterior Window Caulking**	**Cat 2 NF**	**SC Kitchen/Bathroom Exterior Window**	**NA/PS**	**PLM**
101116BH-54A	**Gray Exterior Door Caulking**	**Cat 2 NF**	**SC Cafeteria Exterior Door 12**	**5% Chrysotile**	**PLM**
101116BH-54B	**Gray Exterior Door Caulking**	**Cat 2 NF**	**SC Kitchen Exterior Door**	**NA/PS**	**PLM**
101116BH-55A	Gray Door Soffit Rough Coat	Non-ACM	SC Exterior Door 12	ND	PLM
101116BH-55B	Gray Door Soffit Rough Coat	Non-ACM	SC Exterior Door 12	ND	PLM
101116BH-55C	Gray Door Soffit Rough Coat	Non-ACM	SC Exterior Door 12	ND	PLM
101116BH-56A	Gray Exterior Vent Caulking	Non-ACM	SC Café Exterior Vent Side D Wall	ND / ND	PLM/TEM NOB
101116BH-56B	Gray Exterior Vent Caulking	Non-ACM	SC Café Exterior Vent Side D Wall	ND	PLM
101116BH-57A	Gray Foundation/Brick Wall Caulking	Non-ACM	SC Exterior Side C Foundation/Brick Wall Union	ND	PLM
101116BH-57B	**Gray Foundation/Brick Wall Caulking**	**Cat 2 NF**	**SC Exterior Side C Foundation/Brick Wall Union**	**2% Chrysotile**	**PLM**

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-58A	Gray Foundation Wall	Non-ACM	SC Café Exterior Foundation Wall Side D Wall	ND	PLM
101116BH-58B	Gray Foundation Wall	Non-ACM	SC Café Exterior Foundation Wall Side C Wall	ND	PLM
101116BH-59A	Terracotta Brick	Non-ACM	SC Café Exterior Side D Wall	ND	PLM
101116BH-59B	Terracotta Brick	Non-ACM	SC Café Exterior Side D Wall	ND	PLM
101116BH-60A	Gray Brick Rough	Non-ACM	SC Café Exterior Side D Wall	ND	PLM
101116BH-60B	Gray Brick Rough	Non-ACM	SC Café Exterior Side D Wall	ND	PLM
101116BH-61A	Black Tar/Metal Flashing	Non-ACM	SC Café Exterior Side D behind Brick	ND / ND	PLM/TEM NOB
101116BH-61B	Black Tar/Metal Flashing	Non-ACM	SC Café Exterior Side D behind Brick	ND	PLM
101116BH-62A	**Gray Expansion Wall Caulking**	**Cat 2 NF**	**SC Café Exterior Side D Wall**	**4% Chrysotile**	**PLM**
101116BH-62B	**Gray Expansion Wall Caulking**	**Cat 2 NF**	**SC Exterior Roof Wall by Room W229/Women' Bath**	**NA/PS**	**PLM**
101116BH-63A	**Gray Cementitious Soffit**	**Cat 2 NF**	**SC Exterior Soffit by W229 Room**	**15% Chrysotile**	**PLM**
101116BH-63B	**Gray Cementitious Soffit**	**Cat 2 NF**	**SC Exterior Soffit by W229 Room**	**NA/PS**	**PLM**
101116BH-64A	**Tan Caulking on Metal Fascia**	**Cat 2 NF**	**SC Upper Roof (Roof 1)**	**4% Chrysotile**	**PLM**
101116BH-64B	**Tan Caulking on Metal Fascia**	**Cat 2 NF**	**SC Upper Roof (Roof 1)**	**NA/PS**	**PLM**
101116BH-65A	Black Modified Roof Build Up	Non-ACM	SC Upper Roof (Roof 1) Field Top Layer	ND / ND	PLM/TEM NOB
101116BH-65B	Black Modified Roof Build Up	Non-ACM	SC Upper Roof (Roof 1) Field Top Layer	ND	PLM
101116BH-66A	Yellow Foam Roof Insulation	Non-ACM	SC Upper Roof (Roof 1) Field 2nd Layer	ND	PLM
101116BH-66B	Yellow Foam Roof Insulation	Non-ACM	SC Upper Roof (Roof 1) Field 2nd Layer	ND	PLM
101116BH-67A	Black Roof Build Up	Non-ACM	SC Upper Roof (Roof 1) Field 3rd Layer	ND / ND	PLM/TEM NOB
101116BH-67B	Black Roof Build Up	Non-ACM	SC Upper Roof (Roof 1) Field 3rd Layer	ND	PLM
101116BH-68A	Brown Wood Comprised Insulation	Non-ACM	SC Upper Roof (Roof 1) Field 4th Layer	ND	PLM
101116BH-68B	Brown Wood Comprised Insulation	Non-ACM	SC Upper Roof (Roof 1) Field 5th Layer	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-69A	Black Base Roof Sheet	Non-ACM	SC Upper Roof (Roof 1) Field Bottom Layer	ND / ND	PLM/TEM NOB
101116BH-69B	Black Base Roof Sheet	Non-ACM	SC Upper Roof (Roof 1) Field Bottom Layer	ND	PLM
101116BH-70A	Black Roof Build Up	Non-ACM	SC Upper Roof (Roof 1) Edge Top Layer	ND	PLM
101116BH-70B	**Black Roof Build Up**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Edge Top Layer**	**5% Chrysotile**	**PLM**
101116BH-71A	**Black Pitch Tar**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Edge 3rd Layer**	**15% Chrysotile**	**PLM**
101116BH-71B	**Black Pitch Tar**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Edge 3rd Layer**	**NA/PS**	**PLM**
101116BH-72A	Black Roof Sheet	Non-ACM	SC Upper Roof (Roof 1) Edge 4th Layer	ND / ND	PLM/TEM NOB
101116BH-72B	Black Roof Sheet	Non-ACM	SC Upper Roof (Roof 1) Edge 4th Layer	ND	PLM
101116BH-73A	**Black Roof Base Sheet**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Edge Bottom Layer**	**10% Chrysotile**	**PLM**
101116BH-73B	**Black Roof Base Sheet**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Edge Bottom Layer**	**NA/PS**	**PLM**
101116BH-74A	Black Pitch Tar	Non-ACM	SC Upper Roof (Roof 1) on Lighting Rod	ND / ND	PLM/TEM NOB
101116BH-74B	Black Pitch Tar	Non-ACM	SC Upper Roof (Roof 1) on Lighting Rod	ND	PLM
101116BH-75A	**Black Roof Penetration Flashing Build Up**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Penetration Top Layer**	**8% Chrysotile**	**PLM**
101116BH-75B	**Black Roof Penetration Flashing Build Up**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Penetration Top Layer**	**NA/PS**	**PLM**
101116BH-76A	Black Roof Penetration Build Up	Non-ACM	SC Upper Roof (Roof 1) Penetration 3rd Layer	ND / <0.1% Chrysotile	PLM/TEM NOB
101116BH-76B	Black Roof Penetration Build Up	Non-ACM	SC Upper Roof (Roof 1) Penetration 3rd Layer	ND	PLM
101116BH-77A	**Black Roof Build Up**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Penetration 5th Layer**	**25% Chrysotile**	**PLM**
101116BH-77B	**Black Roof Build Up**	**Cat 1 NF**	**SC Upper Roof (Roof 1) Penetration 5th Layer**	**NA/PS**	**PLM**
101116BH-78A	Black Roof Base Sheet	Non-ACM	SC Upper Roof (Roof 1) Penetration Bottom Layer	ND / ND	PLM/TEM NOB
101116BH-78B	Black Roof Base Sheet	Non-ACM	SC Upper Roof (Roof 1) Penetration Bottom Layer	ND	PLM
101116BH-79A	Black Roof Build Up	Non-ACM	SC Lower Roof (Roof 2) Field Top Layer	ND / ND	PLM/TEM NOB
101116BH-79B	Black Roof Build Up	Non-ACM	SC Lower Roof (Roof 4) Field Top Layer	ND	PLM
101116BH-80A	Yellow Foam Insulation	Non-ACM	SC Lower Roof (Roof 2) Field 2nd Layer	ND	PLM

Sample No.	Material Type	NESHAP Category	Sample Location(s)	Asbestos Content	PLM/TEM
West Campus Student Center					
101116BH-80B	Yellow Foam Insulation	Non-ACM	SC Lower Roof (Roof 3) Perimeter 2nd Layer	ND	PLM
101116BH-81A	Black Roof Build Up	Non-ACM	SC Lower Roof (Roof 2) Field 3rd Layer	ND / ND	PLM/TEM NOB
101116BH-81B	Black Roof Build Up	Non-ACM	SC Lower Roof (Roof 4) Field 3rd Layer	ND	PLM
101116BH-82A	Brown Wood Comprised Insulation	Non-ACM	SC Lower Roof (Roof 2) Field 4th Layer	ND	PLM
101116BH-82B	Brown Wood Comprised Insulation	Non-ACM	SC Lower Roof (Roof 3) Perimeter 4th Layer	ND	PLM
101116BH-83A	Black Roof Base Sheet	Non-ACM	SC Lower Roof (Roof 2) Field 5th Layer	ND / ND	PLM/TEM NOB
101116BH-83B	Black Roof Base Sheet	Non-ACM	SC Lower Roof (Roof 4) Field 5th Layer	ND	PLM
101116BH-84A	**Black Roof Build Up**	**Cat 1 NF**	**SC Lower Roof (Roof 2) Edge Top Layer**	**3% Chrysotile**	**PLM**
101116BH-84B	**Black Roof Build Up**	**Cat 1 NF**	**SC Lower Roof (Roof 3) Edge Top Layer**	**NA/PS**	**PLM**
101116BH-85A	**Black Roof Build Up 2nd Layer**	**Cat 1 NF**	**SC Lower Roof (Roof 2) Edge 3rd Layer**	**3% Chrysotile**	**PLM**
101116BH-85B	**Black Roof Build Up 2nd Layer**	**Cat 1 NF**	**SC Lower Roof (Roof 3) Edge 3rd Layer**	**NA/PS**	**PLM**
101116BH-86A	Black Roof Base Sheet	Non-ACM	SC Lower Roof (Roof 2) Edge 5th Layer	ND / ND	PLM/TEM NOB
101116BH-86B	Black Roof Base Sheet	Non-ACM	SC Lower Roof (Roof 3) Edge 5th Layer	ND	PLM
101116BH-87A	Black Roof Pitched Pocket Tar	Non-ACM	SC Lower Roof (Roof 2) Pitch Pocket	ND / ND	PLM/TEM NOB
101116BH-87B	Black Roof Pitched Pocket Tar	Non-ACM	SC Lower Roof (Roof 2) Pitch Pocket	ND	PLM

Cat 1 NF=Category I Non-Friable Material

Cat 2 NF=Category II Non-Friable Material

NA/Pos Stop=Not Analyzed/ Positive Stop

ND=None
Detected

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Table 2
Summary of Asbestos-Containing Materials Inventory

Material Type	Location(s)	Asbestos Content	Estimated Total Quantity	Comments
East Campus PepsiCo Theatre				
Cementitious Roof Shingles	Surrounding Pitched Roof adjacent to Theatre Roof	35% Chrysotile	136 SF *estimated quantity includes adjacent roof shingles that may potentially be impacted by roof renovations*	
Gray/Black Roof Drain Caulking	Theatre Roof	5% Chrysotile	4 Drains/4 LF	
Loose Black Roofing Paper Debris *Origin of material is from surrounding adjacent pitched roof system*	Theatre Roof	2% Chrysotile	100 SF	
West Campus Student Center				
Pipe Fitting Insulation	Kitchen, Faculty Lounge, Dining Hall, Corridor at Dining Hall, Mail Room, and Bathrooms *Material is assumed to exist above fixed ceilings, behind walls, and within wet walls and pipe chases*	6% Chrysotile	100 EA	
Black Floor Tile Mastic *Associated floor tile is considered contaminated ACM*	Faculty Lounge W229, Kitchen Service Area, Dining Hall, Mail Room 119, and Adjacent Corridor	5% Chrysotile	6,500 SF *estimated quaintly includes associated floor tile*	
Gray Rough Coat Plaster	Behind Panel within Kitchen Walk-in Cooler	3% Chrysotile	320 SF	
Mirror Glue	2nd Floor Men's and Women's Bathrooms	Assumed	6 EA	
Gray Bottom Exterior Window Caulking	Exterior Window Systems	8% Chrysotile	160 LF	
Tan Exterior Window Caulking *inseparable gray caulking is <1% ACM and considered contaminated ACM*	Exterior Window Systems	6% Chrysotile	200 LF *estimated quantity includes associated gray caulking*	
Gray Interior/Exterior Window Glazing	Exterior Window Systems	3% Chrysotile	180 EA	

Material Type	Location(s)	Asbestos Content	Estimated Total Quantity	Comments
West Campus Student Center				
Gray Expansion Wall Caulking	Exterior Brick	4% Chrysotile	100 LF	
Gray Foundation Caulking	Exterior Concrete Foundation and Brick	2% Chrysotile	260 LF	
Gray Exterior Door Caulking	Exterior Door Systems	5% Chrysotile	2 EA	
Gray Cementitious Soffit Paneling	Upper Roof System	2% Chrysotile	200 SF	
Tan Caulking on Metal Fascia	Upper Roof and Exterior Window System outside 2nd Floor Corridor	4% Chrysotile	30 LF	
Layered Roofing at Penetrations and Perimeter Edges (includes built-up, pitch tar, flashings, and base sheet)	Upper Roof (Roof 1) and Lower Roofs (Roofs 2 & 3)	3% – 25% Chrysotile	1,000 SF *estimated quantities only include sections of roofs to be impacted in proposed renovations as depicted in plan A1.03S*	all layers of roofing are considered contaminated ACM

LF = Linear Feet

SF = Square Feet

EA = Each

Table 3
PCB/DEHP-Containing Light Ballasts Inventory

Type	Estimated Quantity
DEHP	152
Total	152

Table 4
Mercury-Containing Equipment Inventory

Type	Estimated Quantity
2' Light Tube	280
High Intensity Discharge (HID) Light	24
Compact Fluorescent Lamp (CFL)	10

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Appendix A

Limitations

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APPENDIX A

Norwalk Community College
188 Richards Avenue, Norwalk, Connecticut

1. This environmental report has been prepared for the exclusive use of The Board of Regents for Higher Education and is subject to, and is issued in connection with the terms and conditions of the original Agreement and all of its provisions. Any use or reliance upon information provided in this report, without the specific written authorization of the Client and Fuss & O'Neill EnviroScience, LLC (EnviroScience) shall be at the User's individual risk. This report should not be used as an abatement specification. All quantities of materials identified during this inspection are approximate.
2. EnviroScience has obtained and relied upon information from multiple sources to form certain conclusions regarding likely environmental issues at and in the vicinity of the subject property in conducting this inspection. Except as otherwise noted, no attempt has been made to verify the accuracy or completeness of such information or verify compliance by any party with federal, state or local laws or regulations.
3. EnviroScience has obtained and relied upon laboratory analytical results in conducting the inspection. This information was used to form conclusions regarding the types and quantities of ACM that must be managed prior to renovation or demolition activities that may disturb these materials at the subject property(ies). EnviroScience has not performed an independent review of the reliability of this laboratory data.
4. Unless otherwise noted, only suspect hazardous materials associated within or located on the building (aboveground) were included in this inspection. Suspect hazardous materials may exist below the ground surface that were not included in the scope of work of this inspection. EnviroScience cannot guarantee all asbestos or suspect hazardous materials were identified within the areas included in the scope of work. Only visible and accessible areas were included in the scope of work for this inspection.
5. The findings, observations and conclusions presented in this report are limited by the scope of services outlined in our original Agreement (March 1, 2016), which reflects schedule and budgetary constraints imposed by Client. Furthermore, the assessment has been conducted in accordance with generally accepted environmental practices. No other warranty, expressed or implied, is made.
6. The conclusions presented in this report are based solely upon information gathered by EnviroScience to date. Should further environmental or other relevant information be discovered at a later date, the Client should immediately bring the information to the EnviroScience's attention. Based upon an evaluation and assessment of relevant information, EnviroScience may modify the letter report and its conclusions.

FUSS & O'NEILL
EnviroScience, LLC

Appendix B

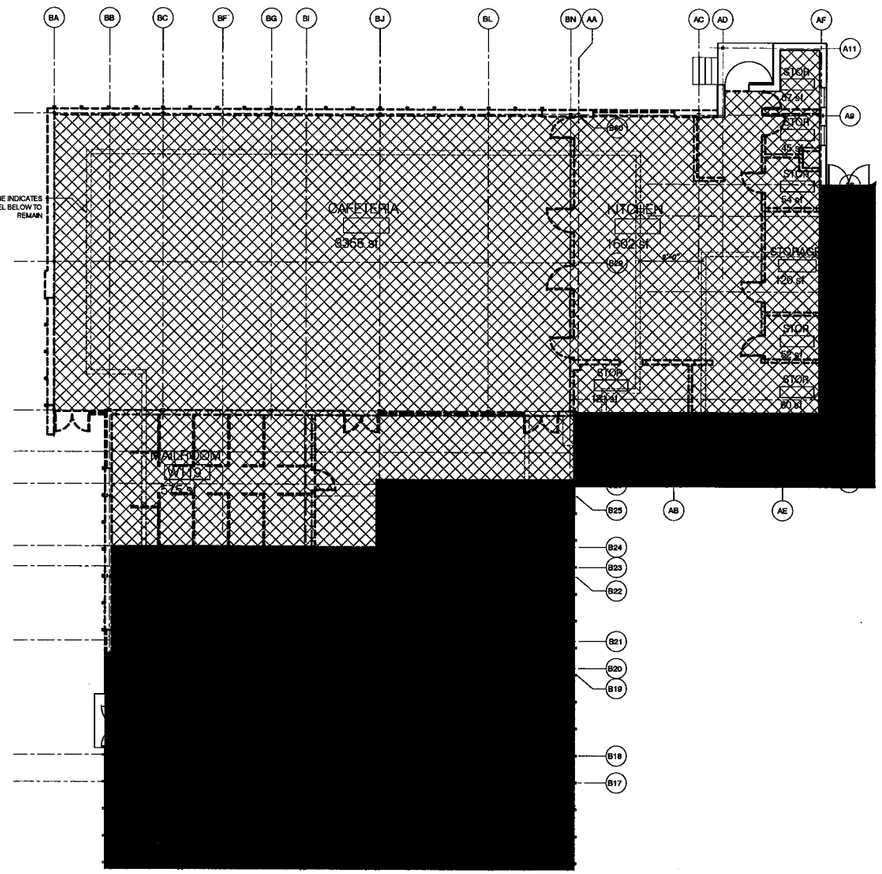
Renovation Drawings A1.01S–A1.03S and A1.01T–A1.03T

DEMOLITION LEGEND:

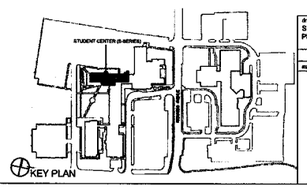
- EXISTING BUILDING TO REMAIN: NO WORK
- REMOVE EXISTING CONSTRUCTION
- FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)
- REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)
- AREA NOT IN CONTRACT

GENERAL DEMOLITION NOTES:

1. REMOVE EXISTING FLOOR TILES, CARPET, RESINOUS FLOORING & WALL BASE WITHIN LIMIT OF WORK. PREPARE EXISTING SLAB AS REQUIRED FOR INSTALLATION OF CEMENT LEVELING COMPOUND AS PER MANUFACTURERS RECOMMENDATIONS.
2. REMOVE EXISTING GYPSUM BOARD CEILINGS, ACOUSTIC & METAL CEILING TILES, SUSPENDED CEILING GRID & ASSOCIATED SUPPORT WITHIN LIMIT OF WORK.
3. REMOVE EXISTING MILLWORK BASE CABINETS, WALL CABINETS, SHELVING & RELATED CASEWORK U.O.N. WITHIN LIMIT OF WORK
4. REMOVE EXISTING VERTICAL BLINDS & CURTAINS AT WINDOWS WITHIN LIMIT OF WORK
5. REMOVE EXISTING DUCTWORK, MECHANICAL PIPING, FINTUBE & FINTUBE ENCLOSURES, PLUMBING, FIXTURES, ASSOCIATED PIPING & ELECTRICAL WITHIN LIMIT OF WORK, SEE MEP DRAWINGS FOR EXTENT
6. REMOVE ALL INTERIOR & EXTERIOR SIGNAGE.
7. REMOVE NOTHING SUSPECTED TO CONTAIN ASBESTOS OR OTHER HAZARDOUS MATERIALS. ADVISE OWNER IF SUCH MATERIALS ARE ENCOUNTERED.
8. SEQUENCE DEMOLITION TO COORDINATE W/ OWNER'S ASBESTOS REMOVAL OPERATIONS. (NOTE: DEMOLITION MAY BE NON-CONTINUOUS)
9. REMOVE ANY MOLDINGS, HOOKS, BRACKETS, AND OTHER MISCELLANEOUS ITEMS FROM ALL SURFACES OF REMAINING CONSTRUCTION.
10. ALL LOOSE FURNITURE IN LIMIT OF WORK SHALL BE REMOVED & DISPOSED OF BY THE BIDDER



01 FIRST FLOOR DEMOLITION PLAN
SCALE: 1/8" = 1'-0"



KEY PLAN

drawing title: STUDENT CENTER 1ST FL DEMO PLAN

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by
Architect
Mitchell/Giurgola Architects, LLP
430 Bedford Road, Suite 111
Pleasantville, NY 10570
914 923 4900

project
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

CAD no.
project no. BI-CTC-487

date: 06/01/16
scale: As indicated
drawn by
approved by
drawing no. A1.01S

DEMOLITION LEGEND:

EXISTING BUILDING TO REMAIN: NO WORK

REMOVE EXISTING CONSTRUCTION

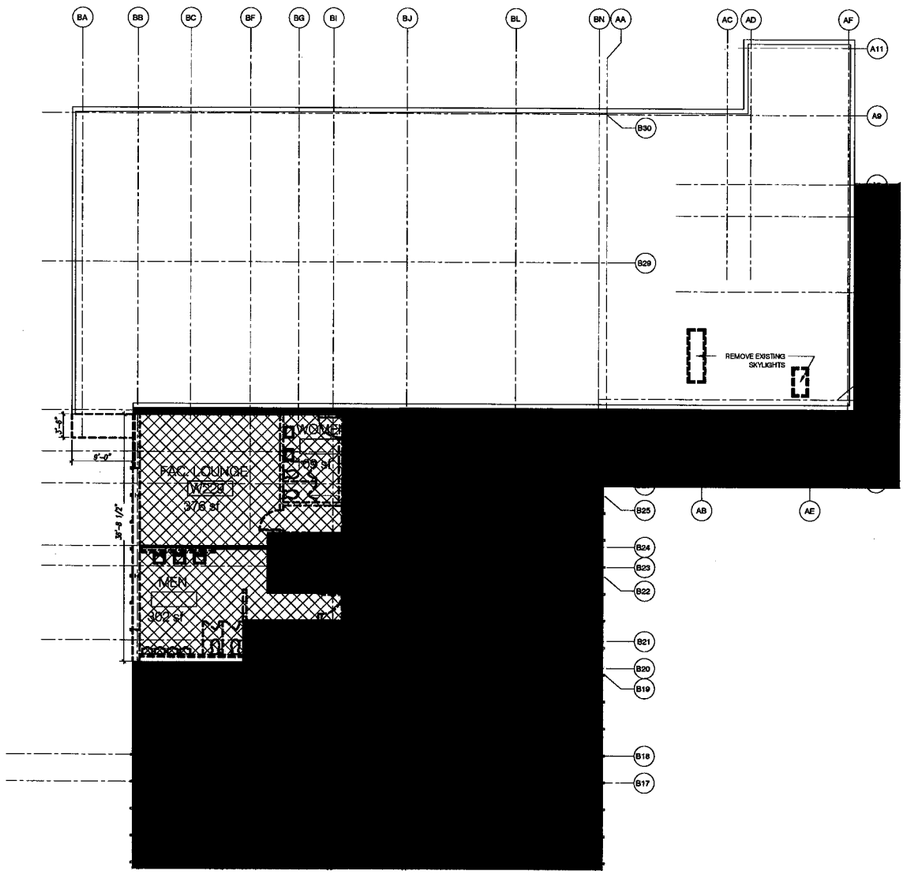
FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)

REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)

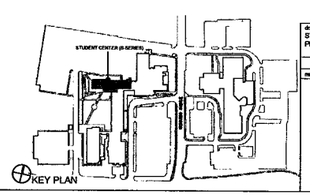
AREA NOT IN CONTRACT

GENERAL DEMOLITION NOTES:

1. REMOVE EXISTING FLOOR TILES, CARPET, RESINOUS FLOORING & WALL BASE WITHIN LIMIT OF WORK. PREPARE EXISTING SLAB AS REQUIRED FOR INSTALLATION OF CEMENT LEVELING COMPOUND AS PER MANUFACTURERS RECOMMENDATIONS.
2. REMOVE EXISTING GYPSUM BOARD CEILINGS, ACOUSTIC & METAL CEILING TILES, SUSPENDED CEILING GRID & ASSOCIATED SUPPORT WITHIN LIMIT OF WORK.
3. REMOVE EXISTING MILLWORK BASE CABINETS, WALL CABINETS, SHELVING & RELATED CASEWORK U.O.N. WITHIN LIMIT OF WORK
4. REMOVE EXISTING VERTICAL BLINDS & CURTAINS AT WINDOWS WITHIN LIMIT OF WORK
5. REMOVE EXISTING DUCTWORK, MECHANICAL PIPING, FINTUBE & FINTUBE ENCLOSURES, PLUMBING, FIXTURES, ASSOCIATED PIPING & ELECTRICAL WITHIN LIMIT OF WORK, SEE MEP DRAWINGS FOR EXTENT
6. REMOVE ALL INTERIOR & EXTERIOR SIGNAGE.
7. REMOVE NOTHING SUSPECTED TO CONTAIN ASBESTOS OR OTHER HAZARDOUS MATERIALS. ADVISE OWNER IF SUCH MATERIALS ARE ENCOUNTERED.
8. SEQUENCE DEMOLITION TO COORDINATE W/ OWNER'S ASBESTOS REMOVAL OPERATIONS. (NOTE: DEMOLITION MAY BE NON-CONTINUOUS)
9. REMOVE ANY MOLDINGS, HOOKS, BRACKETS, AND OTHER MISCELLANEOUS ITEMS FROM ALL SURFACES OF REMAINING CONSTRUCTION.
10. ALL LOOSE FURNITURE IN LIMIT OF WORK SHALL BE REMOVED & DISPOSED OF BY THE BIDDER



01 SECOND FLOOR DEMOLITION PLAN
SCALE: 1/8" = 1'-0"



drawing title: STUDENT CENTER 2ND FL DEMO PLAN

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by
Architect
Mitchell/Giurgola Architects, LLP
600 5th Ave., Suite 711
New York, NY 10048
212 683 4000

date: 09/01/16
scale: As indicated
drawn by:
approved by:
drawing no.: A1.02S

project
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

CAD no.
project no.: SI-CTC-467

DEMOLITION LEGEND:

EXISTING BUILDING TO REMAIN: NO WORK

REMOVE EXISTING CONSTRUCTION

FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)

REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)

AREA NOT IN CONTRACT

GENERAL DEMOLITION NOTES:

1. REMOVE EXISTING FLOOR TILES, CARPET, RESINOUS FLOORING & WALL BASE WITHIN LIMIT OF WORK. PREPARE EXISTING SLAB AS REQUIRED FOR INSTALLATION OF CEMENT LEVELING COMPOUND AS PER MANUFACTURERS RECOMMENDATIONS.
2. REMOVE EXISTING GYPSUM BOARD CEILINGS, ACOUSTIC & METAL CEILING TILES, SUSPENDED CEILING GRID & ASSOCIATED SUPPORT WITHIN LIMIT OF WORK.
3. REMOVE EXISTING MILLWORK BASE CABINETS, WALL CABINETS, SHELVING & RELATED CASEWORK U.O.N. WITHIN LIMIT OF WORK
4. REMOVE EXISTING VERTICAL BLINDS & CURTAINS AT WINDOWS WITHIN LIMIT OF WORK
5. REMOVE EXISTING DUCTWORK, MECHANICAL PIPING, FINTUBE & FINTUBE ENCLOSURES, PLUMBING, FIXTURES, ASSOCIATED PIPING & ELECTRICAL WITHIN LIMIT OF WORK, SEE MEP DRAWINGS FOR EXTENT
6. REMOVE ALL INTERIOR & EXTERIOR SIGNAGE.
7. REMOVE NOTHING SUSPECTED TO CONTAIN ASBESTOS OR OTHER HAZARDOUS MATERIALS. ADVISE OWNER IF SUCH MATERIALS ARE ENCOUNTERED.
8. SEQUENCE DEMOLITION TO COORDINATE W/ OWNER'S ASBESTOS REMOVAL OPERATIONS. (NOTE: DEMOLITION MAY BE NON-CONTINUOUS)
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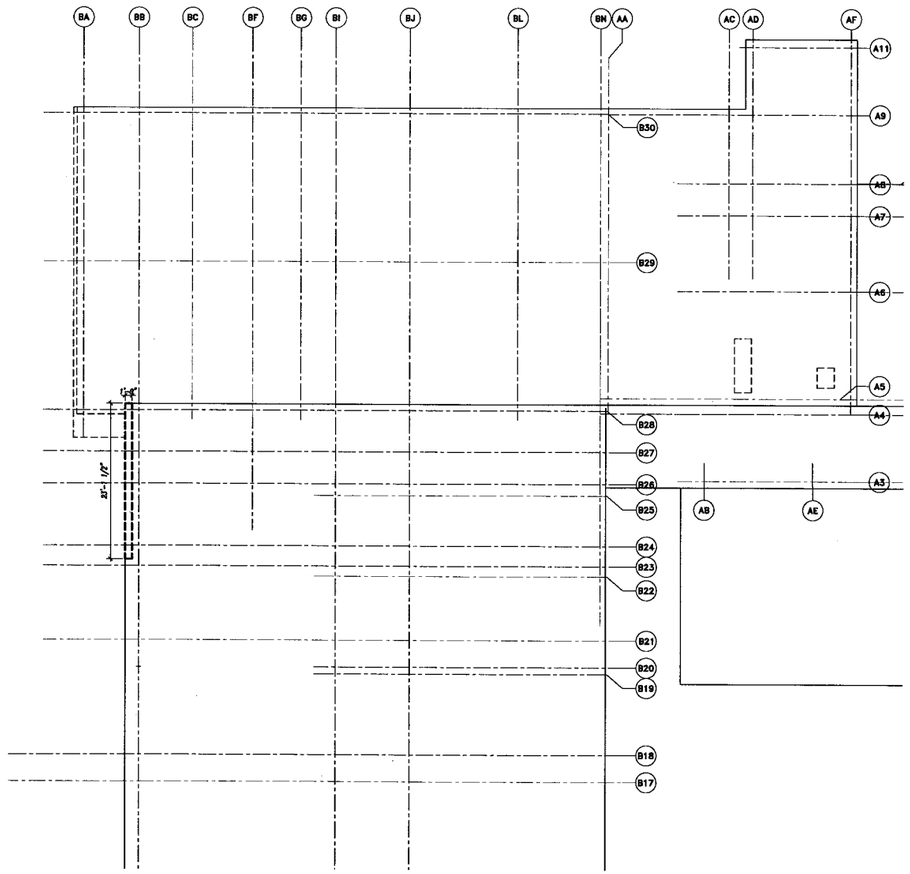
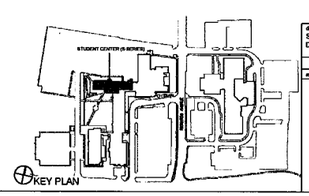
10. ALL LOOSE FURNITURE IN LIMIT OF WORK SHALL BE REMOVED & DISPOSED OF BY THE BIDDER



01 ROOF DEMOLITION PLAN
SCALE: 1/8" = 1'-0"



drawing title: STUDENT CENTER 2ND FL. ROOF DEMO PLAN

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by
Architect
Mitchell/Giurgola Architects, LLP
434 Hudson
New York, NY 10014
212 807 6600

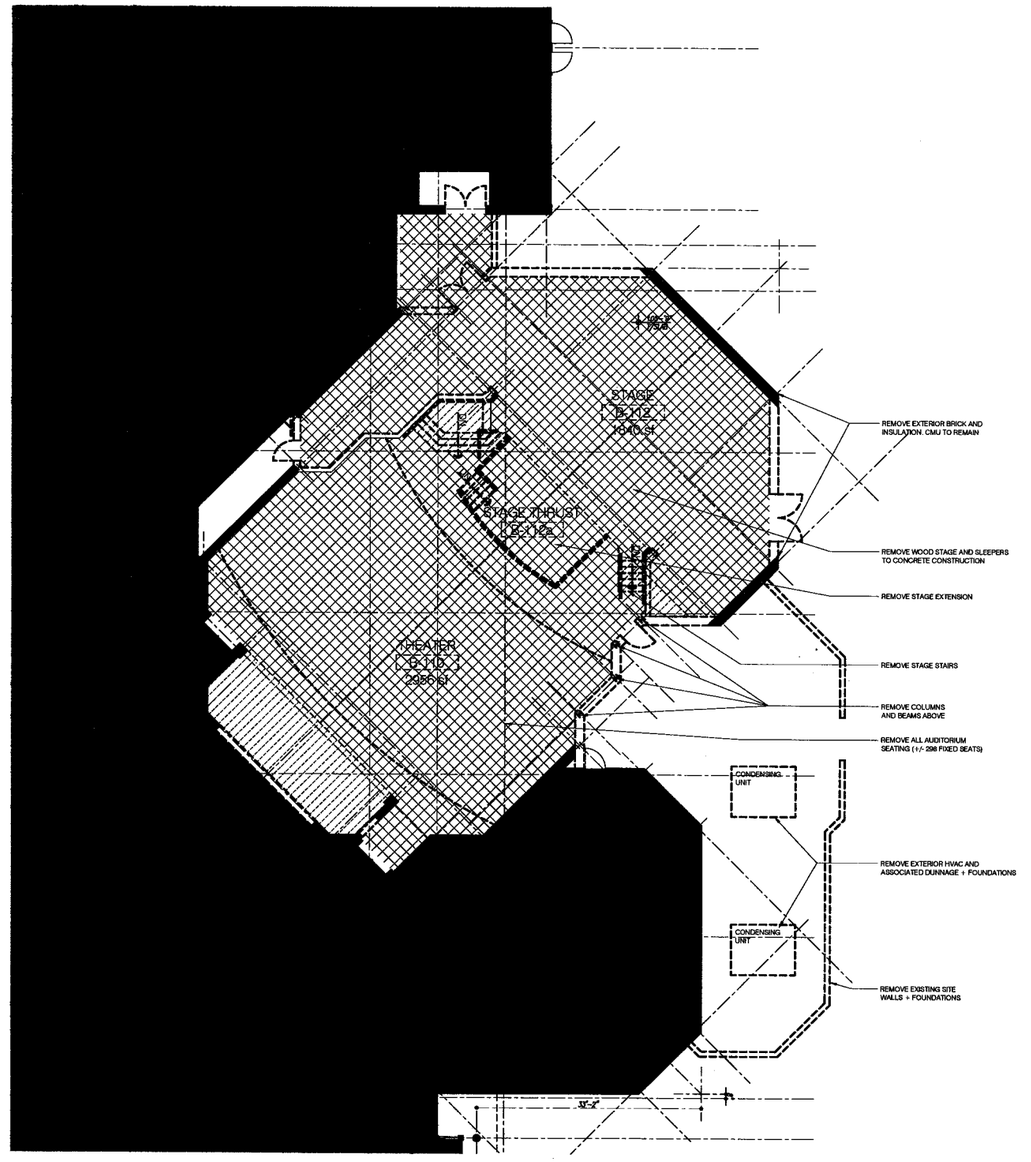
project
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

CAD no.
project no. BI-CTC-467

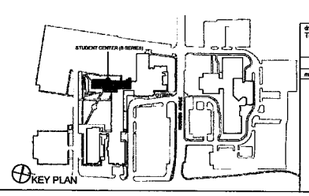
date 09/01/16
scale As indicated
drawn by
approved by
drawing no. A1.03S

DEMOLITION LEGEND:

- EXISTING BUILDING TO REMAIN: NO WORK
- REMOVE EXISTING CONSTRUCTION
- FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)
- REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)
- AREA NOT IN CONTRACT



01 DEMOLITION - THEATER 1ST FLOOR
SCALE: 1/8" = 1'-0"



KEY PLAN

drawing title: THEATER 1ST FL DEMO.

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by
Architect
Mitchell/Giurgola Architects, LLP
420 Mc Ave., Suite 719
New York, NY 10036
212 481-0400

project
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

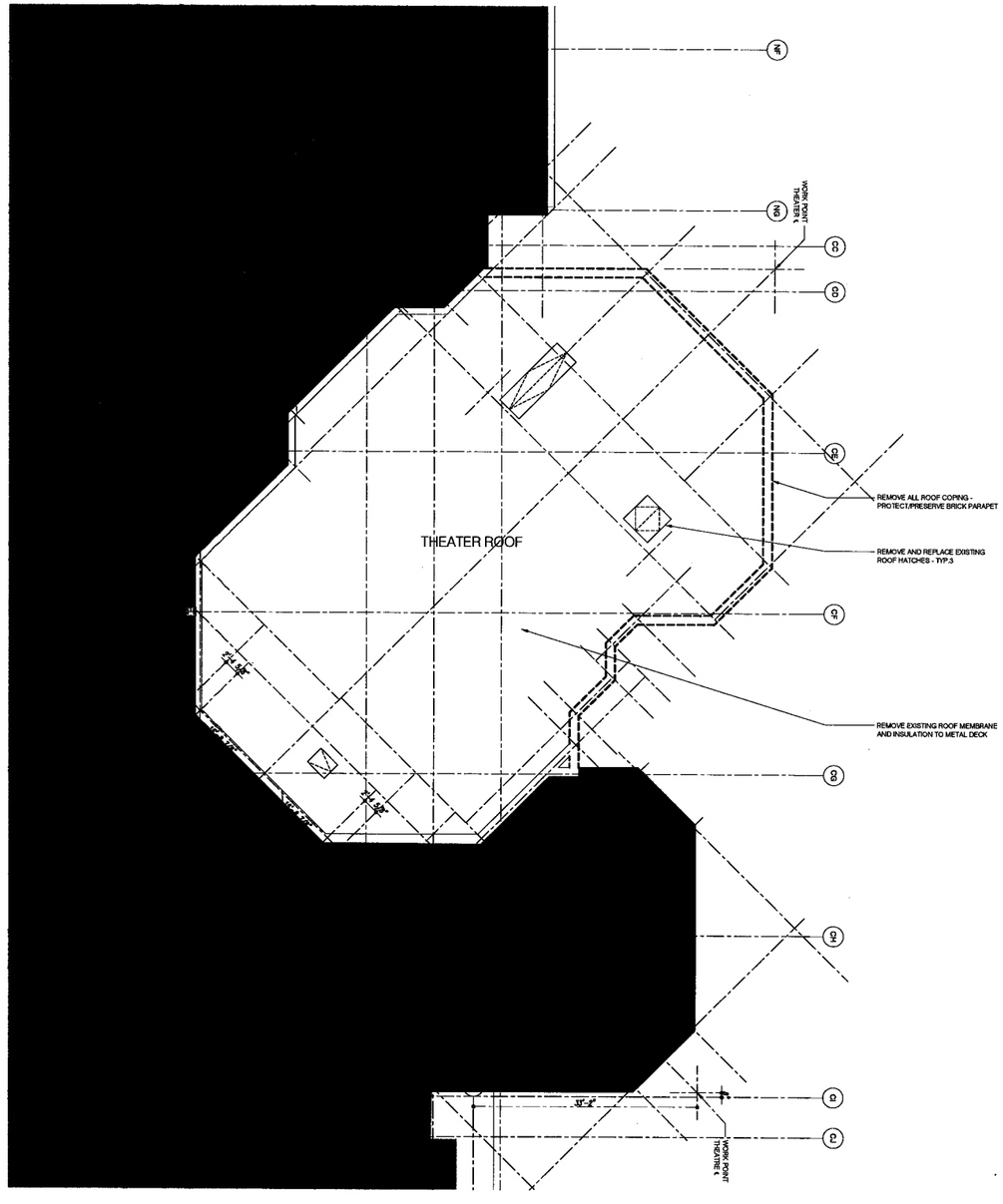
CAD no.

project no.
BI-CTC-467

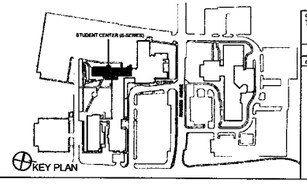
date: 09/01/16
scale: As indicated
drawn by:
approved by:
drawing no.: A1.01T

DEMOLITION LEGEND:

- EXISTING BUILDING TO REMAIN: NO WORK
- REMOVE EXISTING CONSTRUCTION
- FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)
- REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)
- AREA NOT IN CONTRACT



01. DEMOLITION - THEATER ROOF PLAN
SCALE: 1/8" = 1'-0"



KEY PLAN

drawing title: THEATER ROOF DEMO.

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by:
Architect
Mitchell/Giurgola Architects, LLP
420 5th Ave., Suite 711
New York, NY 10018
212 683 4888

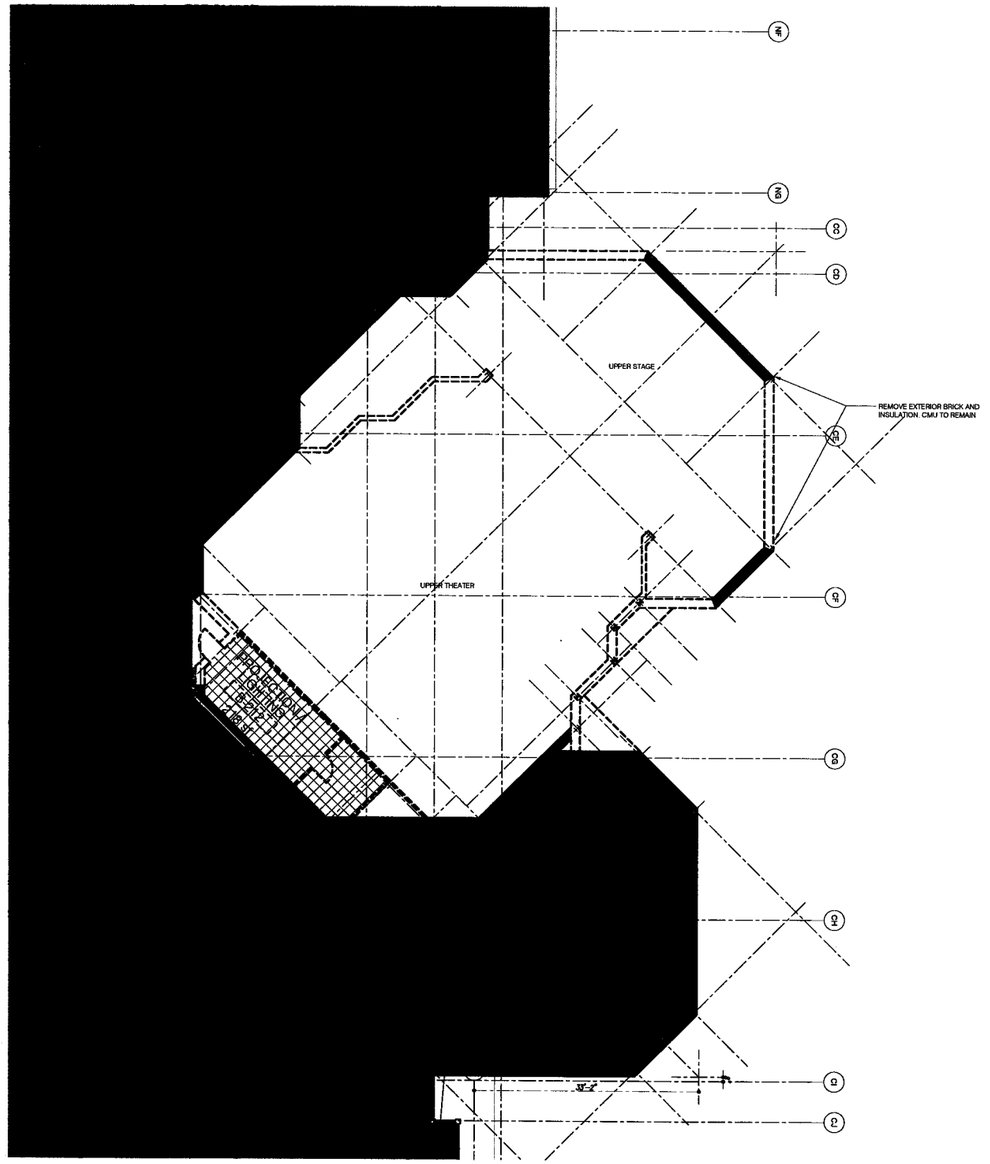
project:
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

CAD no.
project no. 09-CTC-467

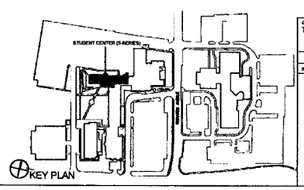
date: 29/01/16
scale: As indicated
drawn by
approved by
drawing no. A1.03T

DEMOLITION LEGEND:

- EXISTING BUILDING TO REMAIN. NO WORK
- REMOVE EXISTING CONSTRUCTION
- FLOOR SLAB AREA TO BE REMOVED (SEE STRUCTURAL DWGS.)
- REMOVE EXIST FLOORING DOWN TO CONCRETE STRUCTURAL SLAB (SEE STRUCTURAL DWGS.)
- AREA NOT IN CONTRACT



01 DEMOLITION - THEATER 2ND FLOOR
SCALE: 1/8" = 1'-0"



drawing title
THEATER 2ND FL DEMO.

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF ADMINISTRATIVE SERVICES

drawing prepared by
Architect
Mitchell/Giurgola Architects, LLP
420 5th Ave., Suite 711
New York, NY 10036
212 563 4900

project
Master Plan Phase III Renovations & Additions Norwalk Community College
188 Richards Avenue
Norwalk, CT 06854-1655

CAD no.
project no.
SI-CTC-467

date
09/01/16
scale
As indicated
drawn by
approved by
drawing no.
A1.02T

FUSS & O'NEILL
EnviroScience, LLC

Appendix C

EnviroScience Inspector Licenses and Accreditations

1001102 01 AV 0.388 **AUTO T6 2 0564 06040-599246 C01-P01105-I

JOHN R. HOBBINS
C/O FUSS & O'NEILL ENVIROSCIENCE, LLC
146 HARTFORD ROAD
MANCHESTER CT 06040-5992

Dear JOHN R. HOBBINS,

Attached you will find your validated certificate for the coming year. Should you have any questions about your certificate renewal, please do not hesitate to write or call:

Department of Public Health
P.O. Box 340308
M.S.#12MQA
Hartford, CT 06134-0308

(860) 509-7603
oplc.dph@ct.gov
www.ct.gov/dph/license

Sincerely,

RAUL PINO, MD, MPH, ACTING COMMISSIONER
DEPARTMENT OF PUBLIC HEALTH

1001102-0001108-0000001 of 0000001-C01-aid00101-0564-01105

EMPLOYER'S COPY

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

NAME
JOHN R. HOBBINS

VALIDATION NO.	CERTIFICATE NO.	CURRENT THROUGH
03-373287	000700	01/31/17

PROFESSION
ASBESTOS CONSULTANT-INSPECTOR

SIGNATURE ACTING COMMISSIONER

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

PURSUANT TO THE PROVISIONS OF THE GENERAL STATUTES OF CONNECTICUT

THE INDIVIDUAL NAMED BELOW IS CERTIFIED
BY THIS DEPARTMENT AS A
ASBESTOS CONSULTANT-INSPECTOR

JOHN R. HOBBINS

CERTIFICATE NO.
000700

CURRENT THROUGH
01/31/17

VALIDATION NO.
03-373287

SIGNATURE ACTING COMMISSIONER

INSTRUCTIONS:

1. Detach and sign each of the cards on this form
2. Display the large card in a prominent place in your office or place of business.
3. The wallet card is for you to carry on your person. If you do not wish to carry the wallet card, place it in a secure place.
4. The employer's copy is for persons who must demonstrate current licensure/certification in order to retain employment or privileges. The employer's card is to be presented to the employer and kept by them as a part of your personnel file. Only one copy of this card can be supplied to you.

WALLET CARD

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

NAME
JOHN R. HOBBINS

VALIDATION NO.	CERTIFICATE NO.	CURRENT THROUGH
03-373287	000700	01/31/17

PROFESSION
ASBESTOS CONSULTANT-INSPECTOR

SIGNATURE ACTING COMMISSIONER

ATC GROUP SERVICES LLC

104 East 25th Street, New York, NY 10010
(212) 353-8280

certifies that

John Robert Hobbins

XX-XX-XXXX

(Social Security Number)

Has Successfully Completed the Accredited 4 Hour EPA-AHERA/ASHARA under 40 CFR 763 and the New York State Department of Health Approved Course for

Asbestos Inspector Refresher

on

September 12, 2016

** Please note that the official record of successful completion is the DOH 2832 Certificate of Asbestos Safety Training.**

This course meets the requirements of TSCA Title II

Certificate#: NYS –RHIIIR-20938 **Exam date: 09-12-16** **Expiration Date: 09-12-17**

Course Location ATC, NYC

Signed: _____

Steve Winograd, Director of Training

Dear SANDRA L GUZMAN,

Attached you will find your validated certificate for the coming year. Should you have any questions about your certificate renewal, please do not hesitate to write or call:

Department of Public Health
P.O. Box 340308
M.S.#12MQA
Hartford, CT 06134-0308

(860) 509-7603
oplc.dph@ct.gov
www.ct.gov/dph/license

Sincerely,

RAUL PINO, MD, MPH, COMMISSIONER
DEPARTMENT OF PUBLIC HEALTH

EMPLOYER'S COPY

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

NAME
SANDRA L GUZMAN

VALIDATION NO	CERTIFICATE NO	CURRENT THROUGH
03-531458	000823	08/31/17

PROFESSION
ASBESTOS CONSULTANT-INSPECTOR

SIGNATURE COMMISSIONER

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

PURSUANT TO THE PROVISIONS OF THE GENERAL STATUTES OF CONNECTICUT

THE INDIVIDUAL NAMED BELOW IS CERTIFIED
BY THIS DEPARTMENT AS A
ASBESTOS CONSULTANT-INSPECTOR

SANDRA L GUZMAN

CERTIFICATE NO
000823

CURRENT THROUGH
08/31/17

VALIDATION NO
03-531458

SIGNATURE COMMISSIONER

INSTRUCTIONS:

1. Detach and sign each of the cards on this form
2. Display the large card in a prominent place in your office or place of business.
3. The wallet card is for you to carry on your person. If you do not wish to carry the wallet card, place it in a secure place.
4. The employer's copy is for persons who must demonstrate current licensure/certification in order to retain employment or privileges. The employer's card is to be presented to the employer and kept by them as a part of your personnel file. Only one copy of this card can be supplied to you.

WALLET CARD

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

NAME
SANDRA L GUZMAN

VALIDATION NO	CERTIFICATE NO.	CURRENT THROUGH
03-531458	000823	08/31/17

PROFESSION
ASBESTOS CONSULTANT-INSPECTOR

SIGNATURE COMMISSIONER

Scanned by CamScanner

ATC GROUP SERVICES LLC

104 East 25th Street, New York, NY 10010
(212) 353-8280

certifies that

Sandra Guzman

XX-XX-XXXX

(Social Security Number)

Has Successfully Completed the Accredited 4 Hour EPA-AHERA/ASHARA under 40 CFR 763 and the New York State Department of Health Approved Course for

Asbestos Inspector Refresher

on

May 31, 2016

**** Please note that the official record of successful completion is the DOH 2832 Certificate of Asbestos Safety Training.****

This course meets the requirements of TSCA Title II

Certificate#: NYS –RHIIIR-20815 **Exam date: 05-31-16** **Expiration Date: 05-31-17**

Course Location ATC, NYC

Signed: _____

Steve Winograd, Director of Training

© 2015 Great Papers

FUSS & O'NEILL
EnviroScience, LLC

Appendix D

Asbestos Laboratory Reports and Chain-of-Custody Forms

OrderID: 041631778

Fuss & O'Neill EnviroScience EMSL Customer No. ENVI54

FUSS & O'NEILL
EnviroScience, LLC

www.fando.com

56 Quarry Road, Trumbull, CT 06611 041631778 Phone (203) 374-3748 Fax (203) 374-4391

ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 1 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-01A	SC Corridor by Cafeteria above Drop Ceiling	Pipe Fitting Insulation
101116BH-01B	SC Kitchen AC Unit 1	Pipe Fitting Insulation
101116BH 01C	SC Kitchen Ac Unit 2	Pipe Fitting Insulation
101116BH-02A	SC Kitchen Storage 1 Room	Backing Paper on Fiberglass Pipe Insulation
101116BH-02B	SC Kitchen Storage 1 Room	Backing Paper on Fiberglass Pipe Insulation
101116BH-03A	SC Kitchen Office	Yellow Carpet Glue
101116BH-03B	SC Room W229	Yellow Carpet Glue
101116BH-04A	SC Cafe	Green Carpet Glue
101116BH-04B	SC Cafe	Green Carpet Glue
101116BH-05A	SC Mail Room Floor	12"x12" White Tan Streaks Floor Tiles
101116BH-05B	SC Room W229 Underneath Carpet	12"x12" White Tan Streaks Floor Tiles
101116BH-06A	SC Café Underneath Carpet	12"x12" Red Floor Tiles
101116BH-06B	SC Café Underneath Carpet	12"x12" Red Floor Tiles
101116BH-07A	SC Café Service Area	12"x12" Green Floor Tiles
101116BH-07B	SC Café Service Area	12"x12" Green Floor Tiles

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: emarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
FAX Results to: 888-838-1160.

Special Instructions: Stop analysis on first positive sample in each homogeneous set of samples unless otherwise noted. Do not layer samples unless indicated. Do Not Point Count. If NOB group sample results are 0% - < 1% by PLM, analyze only "A" group sample above by TEM NOB, per group, unless you are told otherwise.

Samples collected by: Bob Hobbins / Sandra Guzman BH **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: SMB - FX **Date:** 11-19-16 **Time:** 1015A

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

188 also need one on label - "Cafe" on bag

F:\P2007\0369\A9E\Lab Data\NNC Phase III Student Center CoC_rev 3 11.2015.docx

OrderID: 041631778

Fuss & O'Neill EnviroScience EMSL Customer No. ENVI54

FUSS & O'NEILL
EnviroScience, LLC

www.fando.com

56 Quarry Road, Trumbull, CT 066611 041631778 Phone (203) 374-3748 Fax (203) 374-4391

ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 2 of 13

Project Name: Norwalk Community College Phase III Renovations. Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-08A	SC Café Service Area	Yellow Floor Tiles
101116BH-08B	SC Café Service Area	Yellow Floor Tiles
101116BH-09A	SC Room W229SC	Black Floor Tiles Mastic
101116BH-09B	SC Cafe	Black Floor Tiles Mastic
101116BH-09C	SC Corridor by Cafeteria	Black Floor Tiles Mastic
*101116BH-10A	SC Cafe	Green 4" Cove Base
101116BH-10B	SC Cafe	Green 4" Cove Base
101116BH-11A	SC Cafe	Beige Cove Base Glue
101116BH-11B	SC Cafe	Beige Cove Base Glue
101116BH-12A	SC Corridor Outside Cafeteria	Gray 4" Cove Base
101116BH-12B	SC Corridor Outside Cafeteria	Gray 4" Cove Base
101116BH-13A	SC Corridor Outside Cafeteria	Yellow Cove Base Glue
101116BH-13B	SC Corridor Outside Cafeteria	Yellow Cove Base Glue
101116BH-14A	SC 2nd Floor Women's Bathroom Floor	Brown 1"x 2" Ceramic Tiles
101116BH-14B	SC Kitchen Floor Bathroom	Brown 1"x 2" Ceramic Tiles

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: cmarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
FAX Results to: 888-838-1160.

Special Instructions: Stop analysis on first positive sample in each homogeneous set of samples unless otherwise noted. Do not layer samples unless indicated. Do Not Point Count. If NOB group sample results are 0% - < 1% by PLM, analyze only "A" group sample above by TEM NOB, per group, unless you are told otherwise.

Samples collected by: Bob Hobbins / Sandra Guzman BH **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 3 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-15A	SC 2nd Floor Women's Bathroom Floor	Gray Ceramic Grout
101116BH-15B	SC Kitchen Floor Bathroom	Gray Ceramic Grout
101116BH-16A	SC 2nd Floor Men's Bathroom by Room W229	Green 1"x 2" Ceramic Tiles
101116BH-16B	SC 2nd Floor Men's Bathroom by Room W229	Green 1"x 2" Ceramic Tiles
101116BH-17A	SC 2nd Floor Men's Bathroom by Room W229	Gray Ceramic Grout
101116BH-17B	SC 2nd Floor Men's Bathroom by Room W229	Gray Ceramic Grout
101116BH-18A	SC 2nd Floor Men's Bathroom by Room W229	Gray Ceramic Thinset
101116BH-18B	SC 2nd Floor Men's Bathroom by Room W229	Gray Ceramic Grout Thinset
101116BH-19A	SC Kitchen Floor	Brown 6"x 6" Ceramic Floor Tiles
101116BH-19B	SC Kitchen Floor	Brown 6"x 6" Ceramic Floor Tiles
101116BH-20A	SC Kitchen Floor	Gray 6"x 6" Ceramic Floor Tiles Grout
101116BH-20B	SC Kitchen Floor	Gray 6"x 6" Ceramic Floor Tiles Grout
101116BH-21A	SC Kitchen Floor	Gray Ceramic Floor Tiles Thinset
101116BH-21B	SC Kitchen Floor	Gray Ceramic Floor Tiles Thinset
101116BH-22A	SC Room W229	Gray Glazed Block Wall Tiles

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: cmarques@fando.com Do Not Mail Hard Copy Report **Total # of Samples:** 188
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Samples collected by: Bob Hobbins / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 4 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-22B	SC Mail Room	Gray Glazed Block Wall Tiles
101116BH-23A	SC 1st Floor Corridor by Mail Room	Gray Concrete Block
101116BH-23B	SC 2nd Floor Corridor by Room W229	Gray Concrete Block
101116BH-24A	SC 1st Floor Corridor by Mail Room	Gray Concrete Block Grout
101116BH-24B	SC 2nd Floor Corridor by Room W229	Gray Concrete Block Grout
101116BH-25A	SC Kitchen Sink	Brown 6"x 6" Ceramic Wall Tiles
101116BH-25B	SC Kitchen Sink	Brown 6"x 6" Ceramic Wall Tiles
101116BH-26A	SC Kitchen Sink	Gray Wall Ceramic Tiles Grout
101116BH-26B	SC Kitchen Sink	Gray Wall Ceramic Tiles Grout
101116BH-27A	SC Kitchen Bathroom	Blue 4" Ceramic Wall Tiles
101116BH-27B	SC Women's Bathroom by Room W229	Blue 4" Ceramic Wall Tiles
101116BH-28A	SC 2nd Floor Men's Bathroom by Room W229	Green 4" Ceramic Wall Tiles
101116BH-28B	SC 2nd Floor Men's Bathroom by Room W229	Green 4" Ceramic Wall Tiles
101116BH-29A	SC Kitchen Bathroom	White Ceramic Tiles Thinset
101116BH-29B	SC 2nd Floor Men's Bathroom by Room W229	White ceramic Tiles Thinset

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Email Results to: emarques@fando.com Do Not Mail Hard Copy Report **Total # of Samples:** 188
FAX Results to: 888-838-1160.

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Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 5 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-30A	SC Kitchen Bathroom	White Ceramic Tiles Grout
101116BH-30B	SC 2nd Floor Men's Bathroom by Room W229	White Ceramic Tiles Grout
101116BH-31A	SC Cafeteria	White Sheetrock
101116BH-31B	SC Room W229	White Sheetrock
101116BH-32A	SC Cafeteria	White Sheetrock Joint Compound
101116BH-32B	SC Cafeteria	White Sheetrock Joint Compound
101116BH-33A	SC Kitchen	White Wall Panel
101116BH-33B	SC Kitchen	White Wall Panel
101116BH-34A	SC Kitchen	Yellow Wall Panel Glue
101116BH-34B	SC Kitchen	Yellow Wall Panel Glue
101116BH-35A	SC Kitchen Walking Cooler Wall Behind Wall Panel	Gray Rough Coat
101116BH-35B	SC Kitchen Walking Cooler Wall Behind Wall Panel	Gray Rough Coat
101116BH-35C	SC Kitchen Walking Cooler Wall Behind Wall Panel	Gray Rough Coat
101116BH-36A	SC 2nd Floor Men's Bathroom	White Laminate Counter
101116BH-36B	SC Mail Room	White Laminate Counter

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Email Results to: emarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
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Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 6 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-37A	SC 2nd Floor Men's Bathroom	Yellow Laminate Counter Glue
101116BH-37B	SC Mail Room	Yellow Laminate Counter Glue
101116BH-38A	SC 1st Floor Kitchen Bathroom Ceiling	White Plaster Skim Coat
101116BH-38B	SC 1st Floor Kitchen Bathroom Ceiling	White Plaster Skim Coat
101116BH-38C	SC 1st Floor Kitchen Ceiling	White Plaster Skim Coat
101116BH-38D	SC 2nd FL Women's Bathroom by Room W229 Ceiling	White Plaster Skim Coat
101116BH-38E	SC 2nd FL Women's Bathroom by Room W229 Ceiling	White Plaster Skim Coat
101116BH-38F	SC 2nd FL Men's Bathroom By Room W229 Ceiling	White Plaster Skim Coat
101116BH-38G	SC 2nd FL Men's Bathroom By Room W229 Ceiling	White Plaster Skim Coat
101116BH-39A	SC 1st Floor Kitchen Bathroom Ceiling	Light Gray Planter Rough Coat
101116BH-39B	SC 1st Floor Kitchen Bathroom Ceiling	Light Gray Planter Rough Coat
101116BH-39C	SC 1st Floor Kitchen Ceiling	Light Gray Planter Rough Coat
101116BH-39D	SC 2nd FL Women's Bathroom by Room W229 Ceiling	Light Gray Planter Rough Coat
101116BH-39E	SC 2nd FL Women's Bathroom by Room W229 Ceiling	Light Gray Planter Rough Coat
101116BH-39F	SC 2nd FL Men's Bathroom By Room W229 Ceiling	Light Gray Planter Rough Coat

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: cmarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
FAX Results to: 888-838-1160.

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Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

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Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 7 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 10/11/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-39G	SC 2nd FL Men's Bathroom By Room W229 Ceiling	Light Gray Plaster Rough Coat
101116BH-40A	SC 2nd Floor Room W 229	White 1"x1" Ceiling Tiles
101116BH-40B	SC Mail Room	White 1"x1" Ceiling Tiles
101116BH-41A	SC 2nd Floor Corridor By Café	White 2"x4" Ceiling Tiles
101116BH-41B	SC 1st Floor Mail Room	White 2"x4" Ceiling Tiles
101116BH-42A	SC Cafeteria	White 2"x6" Type I Ceiling Tiles
101116BH-42B	SC Cafeteria	White 2"x6" Type I Ceiling Tiles
101116BH-43A	SC Cafeteria	White 2"x6" Type II Ceiling Tiles
101116BH-43B	SC Cafeteria	White 2"x6" Type II Ceiling Tiles
101116BH-44A	SC Mail Room	Brown Ceiling Tiles Glue Daubs
101116BH-44B	SC Cafe	Brown Ceiling Tiles Glue Daubs
101116BH-45A	SC 2nd Floor Room W229	Light Yellow Ceiling Tiles Glue Daubs
101116BH-45B	SC 2nd Floor Room W229	Light Yellow Ceiling Tiles Glue Daubs
101116BH-46A	SC 2nd Floor Room W229	Dark Yellow Ceiling Tiles Glue Daubs
101116BH-46B	SC 2nd Floor Room W229	Dark Yellow Ceiling Tiles Glue Daubs

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Email Results to: cmarques@fando.com Do Not Mail Hard Copy Report **Total # of Samples:** 188
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Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 8 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-47A	SC Room W229	Black Window Sill
101116BH-47B	SC Cafe	Black Window Sill
101116BH-48A	SC Room W229	Gray Window Sill Grout
101116BH-48B	SC Cafe	Gray Window Sill Grout
101116BH-49A	SC Café Window	Gray Interior/Exterior Window Glazing
101116BH-49B	SC Room W229	Gray Interior Window Glazing
101116BH-50A	SC 2nd FL Men's Bathroom Window	White Window Glazing
101116BH-50B	SC 2nd FL Men's Bathroom Window	White Window Glazing
101116BH-51A	SC Café Exterior Side C Window System	Gray Exterior Window Caulking
101116BH-51B	SC Mail Room Exterior Window System	Gray Exterior Window Caulking
101116BH-52A	SC Café Exterior Side C Window System	Tan Exterior Window Caulking
101116BH-52B	SC Mail Room Exterior Window System	Tan Exterior Window Caulking
101116BH-53A	SC Café Exterior Window	Gray Bottom Exterior Window Caulking
101116BH-53B	SC Kitchen/Bathroom Exterior Window	Gray Bottom Exterior Window Caulking
101116BH-54A	SC Cafeteria Exterior Door 12	Gray Exterior Door Caulking

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 9 of 13

Project Name: Norwalk Community College Phase III Renovations Project No 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-54B	SC Kitchen Exterior Door	Gray Exterior Door Caulking
101116BH 55A	SC Exterior Door 12	Gray Door Soffit Rough Coat
101116BH-55B	SC Exterior Door 12	Gray Door Soffit Rough Coat
101116BH-55C	SC Exterior Door 12	Gray Door Soffit Rough Coat
101116BH-56A	SC Café Exterior Vent Side D Wall	Gray Exterior Vent caulking
101116BH-56B	SC Café Exterior Vent Side D Wall	Gray Exterior Vent Caulking
101116BH-57A	SC Exterior Side C Foundation/Brick Wall Union	Gray Foundation/ Brick Wall Caulking
101116BH-57B	SC Exterior Side C Foundation/Brick Wall Union	Gray Foundation/ Brick Wall Caulking
101116BH-58A	SC Café Exterior Foundation Wall Side D Wall	Gray Foundation Wall
101116BH-58B	SC Café Exterior Foundation Wall Side C Wall	Gray Foundation Wall
101116BH 59A	SC Café Exterior Side D Wall	Terracotta Brick
101116BH-59B	SC Café Exterior Side D Wall	Terracotta Brick
101116BH-60A	SC Café Exterior Side D Wall	Gray Brick Rough
101116BH-60B	SC Café Exterior Side D Wall	Gray Brick Rough
101116BH-61A	SC Café Exterior Side D Behind Brick	Black Tar/Metal Flashing

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-61B	SC Café Exterior Side D Behind Brick	Black Tar/Metal Flashing
101116BH-62A	SC Café Exterior Side D Wall	Gray Expansion Wall Caulking
101116BH-62B	SC Exterior Roof Wall by Room W229/Women' Bath	Gray Expansion Wall Caulking
101116BH-63A	SC Exterior Soffit by W229 Room	Gray Cementitious Soffit
101116BH-63B	SC Exterior Soffit by W229 Room	Gray Cementitious Soffit
101116BH-64A	SC Upper Roof (Roof 1)	Tan Caulking on Metal Fascia
101116BH-64B	SC Upper Roof (Roof 1)	Tan Caulking on Metal Fascia
101116BH-65A	SC Upper Roof (Roof 1) Field Top Layer	Black Modified Roof Build Up
101116BH-65B	SC Upper Roof (Roof 1) Field Top Layer	Black Modified Roof Build Up
101116BH-66A	SC Upper Roof (Roof 1) Field 2nd Layer	Yellow Foam Roof Insulation
101116BH-66B	SC Upper Roof (Roof 1) Edge 2nd Layer	Yellow Foam Roof Insulation
101116BH-67A	SC Upper Roof (Roof 1) Field 3rd Layer	Black Roof Build up
101116BH-67B	SC Upper Roof (Roof 1) Field 3rd Layer	Black Roof Build up
101116BH-68A	SC Upper Roof (Roof 1) Field 4th Layer	Brown Wood Comprised Insulation
101116BH-68B	SC Upper Roof (Roof 1) Edge 5th Layer	Brown Wood Comprised Insulation

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

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Samples collected by: Bob Hobbins / Sandra Guzman BH **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

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Sheet 11 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-69A	SC Upper Roof (Roof 1) Field Bottom Layer	Black Base Roof Sheet
101116BH-69B	SC Upper Roof (Roof 1) Field Bottom Layer	Black Base Roof Sheet
101116BH-70A	SC Upper Roof (Roof 1) Edge Top Layer	Black Roof Build Up
101116BH-70B	SC Upper Roof (Roof 1) Edge Top Layer	Black Roof Build Up
101116BH-71A	SC Upper Roof (Roof 1) Edge 3rd Layer	Black Pitch Tar
101116BH-71B	SC Upper Roof (Roof 1) Edge 3rd Layer	Black Pitch Tar
101116BH-72A	SC Upper Roof (Roof 1) Edge 4th Layer	Black Roof Sheet
101116BH-72B	SC Upper Roof (Roof 1) Edge 4th Layer	Black Roof Sheet
101116BH-73A	SC Upper Roof (Roof 1) Edge Bottom Layer	Black Roof Base Sheet
101116BH-73B	SC Upper Roof (Roof 1) Edge Bottom Layer	Black Roof Base Sheet
101116BH-74A	SC Upper Roof (Roof 1) On Lighting Rod	Black Tar Pitch
101116BH-74B	SC Upper Roof (Roof 1) On Lighting Rod	Black Tar Pitch
101116BH-75A	SC Upper Roof (Roof 1) Penetration Top Layer	Black Roof Penetration Flashing Build Up
101116BH-75B	SC Upper Roof (Roof 1) Penetration Top Layer	Black Roof Penetration Flashing Build Up
101116BH-76A	SC Upper Roof (Roof 1) Penetration 3rd Layer	Black Roof Penetration Build Up

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: emarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
FAX Results to: 888-838-1160.

Special Instructions: Stop analysis on first positive sample in each homogeneous set of samples unless otherwise noted. Do not layer samples unless indicated. Do Not Point Count. If NOB group sample results are 0% - < 1% by PLM, analyze only "A" group sample above by TEM NOB, per group, unless you are told otherwise.

Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 12 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-76B	SC Upper Roof (Roof 1) Penetration 3rd Layer	Black Roof Penetration Build Up
101116BH-77A	SC Upper Roof (Roof 1) Penetration 5th Layer	Black Roof Build Up
101116BH-77B	SC Upper Roof (Roof 1) Penetration 5th Layer	Black Roof Build Up
101116BH-78A	SC Upper Roof (Roof 1) Penetration Bottom Layer	Black Roof Base Sheet
101116BH-78B	SC Upper Roof (Roof 1) Penetration Bottom Layer	Black Roof Base Sheet
101116BH-79A	SC Lower Roof (Roof 2) Field Top Layer	Black Roof Build Up
101116BH-79B	SC Lower Roof (Roof 4) Field Top Layer	Black Roof Build Up
101116BH-80A	SC Lower Roof (Roof 2) Field 2nd Layer	Yellow Foam Insulation
101116BH-80B	SC Lower Roof (Roof 3) Perimeter 2nd Layer	Yellow Foam Insulation
101116BH-81A	SC Lower Roof (Roof 2) Field 3rd Layer	Black Roof Build Up
101116BH-81B	SC Lower Roof (Roof 4) Field 3rd Layer	Black Roof Build Up
101116BH-82A	SC Lower Roof (Roof 2) Field 4th Layer	Brown Wood Comprised Insulation
101116BH-82B	SC Lower Roof (Roof 3) Perimeter 4th Layer	Brown Wood Comprised Insulation
101116BH-83A	SC Lower Roof (Roof 2) Field 5th Layer	Black Roof Base Sheet
101116BH-83B	SC Lower Roof (Roof 4) Field 5th Layer	Black Roof Base Sheet

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

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Email Results to: emarques@fando.com Do Not Mail Hard Copy Report **Total # of Samples:** 188
FAX Results to: 888-838-1160.

Special Instructions: Stop analysis on first positive sample in each homogeneous set of samples unless otherwise noted. Do not layer samples unless indicated. Do Not Point Count. If NOB group sample results are 0% - < 1% by PLM, analyze only "A" group sample above by TEM NOB. per group, unless you are told otherwise.

Samples collected by: Bob Hobbins / Sandra Guzman BH Date: 10/11/2016 Time: _____

Samples Sent by: Bob Hobbins BH Date: 11/18/2016 Time: _____

Samples Received by: _____ Date: _____ Time: _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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ASBESTOS BULK SAMPLE CHAIN OF CUSTODY FORM

Sheet 13 of 13

Project Name: Norwalk Community College Phase III Renovations Project No. 20070369.A9E Date: 11/18/2016

Site Address: 188 Richards Avenue, Norwalk CT Building Name/Number: Student Center (SC) Project Manager: Miguel Marques

Sample ID	Sample Location	Type of Material
101116BH-84A	SC Lower Roof (Roof 2) Edge Top Layer	Black Roof Build Up
101116BH-84B	SC Lower Roof (Roof 3) Edge Top Layer	Black Roof Build Up
101116BH-85A	SC Lower Roof (Roof 2) Edge 3rd Layer	Black Roof Build Up 2nd Layer
101116BH-85B	SC Lower Roof (Roof 3) Edge 3rd Layer	Black Roof Build Up 2nd Layer
101116BH-86A	SC Lower Roof (Roof 2) Edge 5th Layer	Black Roof Base Sheet
101116BH-86B	SC Lower Roof (Roof 3) Edge 5th Layer	Black Roof Base Sheet
101116BH-87A	SC Lower Roof (Roof 2) Pitch Pocket	Black Roof Pitched Pocket Tar
101116BH-87B	SC Lower Roof (Roof 2) Pitch Pocket	Black Roof Pitched Pocket Tar

Analysis Method: ☒ PLM ☐ TEM ☐ Other _____ Turnaround Time: 24 hour

Based on the turnaround time indicated above, analyses are due to EnviroScience on or before this date: _____ Please call EnviroScience if analyses will not be completed for requested TAT at (203) 374 - 3748.

Email Results to: emarques@fando.com **Do Not Mail Hard Copy Report** **Total # of Samples:** 188
FAX Results to: 888-838-1160.

Special Instructions: Stop analysis on first positive sample in each homogeneous set of samples unless otherwise noted. Do not layer samples unless indicated. Do Not Point Count. If NOB group sample results are 0% - < 1% by PLM, analyze only "A" group sample above by TEM NOB, per group, unless you are told otherwise.

Samples collected by: Bob Hobbins BH / Sandra Guzman **Date:** 10/11/2016 **Time:** _____

Samples Sent by: Bob Hobbins BH **Date:** 11/18/2016 **Time:** _____

Samples Received by: _____ **Date:** _____ **Time:** _____

Shipped To: ☒ EMSL State NJ ☐ Other _____

Method of Shipment: ☒ FedEx ☐ Lab Drop Off ☐ Other _____

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Attn:	Miguel Marques	Phone:	(860) 646-2469
	Fuss & O'Neill EnviroScience, LLC	Fax:	(888) 838-1160
	146 Hartford Road	Collected:	11/18/2016
	Manchester, CT 06040	Received:	11/19/2016
		Analyzed:	11/25/2016

Proj: Norwalk Community College Phase III Renovations - 188 Richards Avenue, Norwalk, CT - Student Center (SC)

Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-01A ***Lab Sample ID:*** **041631778-0001**

Sample Description: SC Corridor by Cafeteria above Drop Ceiling/Pipe Fitting Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	94%	6% Chrysotile	

Client Sample ID: 101116BH-01B ***Lab Sample ID:*** **041631778-0002**

Sample Description: SC Kitchen AC Unit 1/Pipe Fitting Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-01C ***Lab Sample ID:*** **041631778-0003**

Sample Description: SC Kitchen AC Unit 2/Pipe Fitting Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-02A ***Lab Sample ID:*** **041631778-0004**

Sample Description: SC Kitchen Storage 1 Room/Backing Paper on Fiberglass Pipe Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	90%	10%	None Detected	

Client Sample ID: 101116BH-02B ***Lab Sample ID:*** **041631778-0005**

Sample Description: SC Kitchen Storage 1 Room/Backing Paper on Fiberglass Pipe Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	85%	15%	None Detected	

Client Sample ID: 101116BH-03A ***Lab Sample ID:*** **041631778-0006**

Sample Description: SC Kitchen Office/Yellow Carpet Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Yellow	0.0%	100%	None Detected	

Client Sample ID: 101116BH-03B ***Lab Sample ID:*** **041631778-0007**

Sample Description: SC Room W229/Yellow Carpet Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

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Project ID:	

Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-04A ***Lab Sample ID:*** **041631778-0008**
Sample Description: SC Café/Green Carpet Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Green	0.0%	100%	None Detected	

Client Sample ID: 101116BH-04B ***Lab Sample ID:*** **041631778-0009**
Sample Description: SC Café/Green Carpet Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-05A ***Lab Sample ID:*** **041631778-0010**
Sample Description: SC Mail Room Floor/12"x12" White Tan Streaks Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	White	0.0%	100%	None Detected	

Client Sample ID: 101116BH-05B ***Lab Sample ID:*** **041631778-0011**
Sample Description: SC Room W229 underneath Carpet/12"x12" White Tan Streaks Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	Recommend TEM.

Client Sample ID: 101116BH-06A ***Lab Sample ID:*** **041631778-0012**
Sample Description: SC Cafe underneath Carpet/12"x12" Red Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Red	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Red	0.0%	100%	None Detected	

Client Sample ID: 101116BH-06B ***Lab Sample ID:*** **041631778-0013**
Sample Description: SC Cafe underneath Carpet/12"x12" Red Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Red	0%	100%	None Detected	

Client Sample ID: 101116BH-07A ***Lab Sample ID:*** **041631778-0014**
Sample Description: SC Cafe Service Area/12"x12" Green Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Green	0.0%	100%	None Detected	

Client Sample ID: 101116BH-07B ***Lab Sample ID:*** **041631778-0015**
Sample Description: SC Cafe Service Area/12"x12" Green Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

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Project ID:	

Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-08A ***Lab Sample ID:*** **041631778-0016**
Sample Description: SC Cafe Service Area/Yellow Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	Sample appears to be mastic
TEM Grav. Reduction	11/22/2016	Yellow	0.0%	100%	None Detected	

Client Sample ID: 101116BH-08B ***Lab Sample ID:*** **041631778-0017**
Sample Description: SC Cafe Service Area/Yellow Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-09A ***Lab Sample ID:*** **041631778-0018**
Sample Description: SC Room W229SC/Black Floor Tiles Mastic

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Black	0%	100%	None Detected	
TEM Grav. Reduction	11/25/2016	Black	0.0%	100%	<0.25% Chrysotile	

Client Sample ID: 101116BH-09B ***Lab Sample ID:*** **041631778-0019**
Sample Description: SC Café/Black Floor Tiles Mastic

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Black	0%	95%	5% Chrysotile	The sample group is not homogeneous

Client Sample ID: 101116BH-09C ***Lab Sample ID:*** **041631778-0020**
Sample Description: SC Corridor by Cafeteria/Black Floor Tiles Mastic

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-10A ***Lab Sample ID:*** **041631778-0021**
Sample Description: SC Café/Green 4" Cove Base

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-10B ***Lab Sample ID:*** **041631778-0022**
Sample Description: SC Café/Green 4" Cove Base

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-11A ***Lab Sample ID:*** **041631778-0023**
Sample Description: SC Café/Beige Cove Base Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Beige	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Beige	0.0%	100%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-11B **Lab Sample ID:** 041631778-0024
Sample Description: SC Café/Beige Cove Base Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Beige	0%	100%	None Detected	

Client Sample ID: 101116BH-12A **Lab Sample ID:** 041631778-0025
Sample Description: SC Corridor Outside Cafeteria/Gray 4" Cove Base

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-12B **Lab Sample ID:** 041631778-0026
Sample Description: SC Corridor Outside Cafeteria/Gray 4" Cove Base

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-13A **Lab Sample ID:** 041631778-0027
Sample Description: SC Corridor Outside Cafeteria/Yellow Cove Base Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Yellow	0.0%	100%	None Detected	

Client Sample ID: 101116BH-13B **Lab Sample ID:** 041631778-0028
Sample Description: SC Corridor Outside Cafeteria/Yellow Cove Base Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-14A **Lab Sample ID:** 041631778-0029
Sample Description: SC 2nd Floor Women's Bathroom Floor/Brown 1"x2" Ceramic Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	0%	100%	None Detected	

Client Sample ID: 101116BH-14B **Lab Sample ID:** 041631778-0030
Sample Description: SC Kitchen Floor Bathroom/Brown 1"x2" Ceramic Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	0%	100%	None Detected	

Client Sample ID: 101116BH-15A **Lab Sample ID:** 041631778-0031
Sample Description: SC 2nd Floor Women's Bathroom Floor/Gray Ceramic Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-15B ***Lab Sample ID:*** **041631778-0032**
Sample Description: SC Kitchen Floor Bathroom/Gray Ceramic Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-16A ***Lab Sample ID:*** **041631778-0033**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Green 1"x2" Ceramic Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-16B ***Lab Sample ID:*** **041631778-0034**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Green 1"x2" Ceramic Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-17A ***Lab Sample ID:*** **041631778-0035**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Gray Ceramic Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-17B ***Lab Sample ID:*** **041631778-0036**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Gray Ceramic Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-18A ***Lab Sample ID:*** **041631778-0037**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Gray Ceramic Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-18B ***Lab Sample ID:*** **041631778-0038**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Gray Ceramic Grout Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-19A ***Lab Sample ID:*** **041631778-0039**
Sample Description: SC Kitchen Floor/Brown 6"x6" Ceramic Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	0%	100%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-19B ***Lab Sample ID:*** **041631778-0040**
Sample Description: SC Kitchen Floor/Brown 6"x6" Ceramic Floor Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	0%	100%	None Detected	

Client Sample ID: 101116BH-20A ***Lab Sample ID:*** **041631778-0041**
Sample Description: SC Kitchen Floor/Gray 6"x6" Ceramic Floor Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-20B ***Lab Sample ID:*** **041631778-0042**
Sample Description: SC Kitchen Floor/Gray 6"x6" Ceramic Floor Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-21A ***Lab Sample ID:*** **041631778-0043**
Sample Description: SC Kitchen Floor/Gray Ceramic Floor Tiles Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-21B ***Lab Sample ID:*** **041631778-0044**
Sample Description: SC Kitchen Floor/Gray Ceramic Floor Tiles Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-22A ***Lab Sample ID:*** **041631778-0045**
Sample Description: SC Room W229/Gray Glazed Block Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-22B ***Lab Sample ID:*** **041631778-0046**
Sample Description: SC Mail Room/Gray Glazed Block Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-23A ***Lab Sample ID:*** **041631778-0047**
Sample Description: SC 1st Floor Corridor by Mail Room/Gray Concrete Block

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-23B ***Lab Sample ID:*** **041631778-0048**
Sample Description: SC 2nd Floor Corridor by Room W229/Gray Concrete Block

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-24A ***Lab Sample ID:*** **041631778-0049**
Sample Description: SC 1st Floor Corridor by Mail Room/Gray Concrete Block Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-24B ***Lab Sample ID:*** **041631778-0050**
Sample Description: SC 2nd Floor Corridor by Room W229/Gray Concrete Block Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-25A ***Lab Sample ID:*** **041631778-0051**
Sample Description: SC Kitchen Sink/Brown 6"x6" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	0%	100%	None Detected	

Client Sample ID: 101116BH-25B ***Lab Sample ID:*** **041631778-0052**
Sample Description: SC Kitchen Sink/Brown 6"x6" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	0%	100%	None Detected	

Client Sample ID: 101116BH-26A ***Lab Sample ID:*** **041631778-0053**
Sample Description: SC Kitchen Sink/Gray Wall Ceramic Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-26B ***Lab Sample ID:*** **041631778-0054**
Sample Description: SC Kitchen Sink/Gray Wall Ceramic Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-27A ***Lab Sample ID:*** **041631778-0055**
Sample Description: SC Kitchen Bathroom/Blue 4" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Blue	0%	100%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-27B ***Lab Sample ID:*** **041631778-0056**
Sample Description: SC Women's Bathroom by Room W229/Blue 4" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Blue	0%	100%	None Detected	

Client Sample ID: 101116BH-28A ***Lab Sample ID:*** **041631778-0057**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Green 4" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-28B ***Lab Sample ID:*** **041631778-0058**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/Green 4" Ceramic Wall Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Green	0%	100%	None Detected	

Client Sample ID: 101116BH-29A ***Lab Sample ID:*** **041631778-0059**
Sample Description: SC Kitchen Bathroom/White Ceramic Tiles Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-29B ***Lab Sample ID:*** **041631778-0060**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/White Ceramic Tiles Thinset

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-30A ***Lab Sample ID:*** **041631778-0061**
Sample Description: SC Kitchen Bathroom/White Ceramic Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-30B ***Lab Sample ID:*** **041631778-0062**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229/White Ceramic Tiles Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-31A ***Lab Sample ID:*** **041631778-0063**
Sample Description: SC Cafeteria/White Sheetrock

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown/White	25%	75%	None Detected	

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Client Sample ID: 101116BH-31B ***Lab Sample ID:*** **041631778-0064**
Sample Description: SC Room W229/White Sheetrock

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown/White	20%	80%	None Detected	

Client Sample ID: 101116BH-32A ***Lab Sample ID:*** **041631778-0065**
Sample Description: SC Cafeteria/White Sheetrock Joint Compound

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-32B ***Lab Sample ID:*** **041631778-0066**
Sample Description: SC Cafeteria/White Sheetrock Joint Compound

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-33A ***Lab Sample ID:*** **041631778-0067**
Sample Description: SC Kitchen/White Wall Panel

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	40%	60%	None Detected	

Client Sample ID: 101116BH-33B ***Lab Sample ID:*** **041631778-0068**
Sample Description: SC Kitchen/White Wall Panel

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	35%	65%	None Detected	

Client Sample ID: 101116BH-34A ***Lab Sample ID:*** **041631778-0069**
Sample Description: SC Kitchen/Yellow Wall Panel Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-34B ***Lab Sample ID:*** **041631778-0070**
Sample Description: SC Kitchen/Yellow Wall Panel Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-35A ***Lab Sample ID:*** **041631778-0071**
Sample Description: SC Kitchen Walking Cooler Wall behind Wall Panel/Gray Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	97%	3% Chrysotile	

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Client Sample ID: 101116BH-35B ***Lab Sample ID:*** **041631778-0072**
Sample Description: SC Kitchen Walking Cooler Wall behind Wall Panel/Gray Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-35C ***Lab Sample ID:*** **041631778-0073**
Sample Description: SC Kitchen Walking Cooler Wall behind Wall Panel/Gray Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-36A ***Lab Sample ID:*** **041631778-0074**
Sample Description: SC 2nd Floor Men's Bathroom/White Laminate Counter

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown/White	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Brown/White	0.0%	100%	None Detected	

Client Sample ID: 101116BH-36B ***Lab Sample ID:*** **041631778-0075**
Sample Description: SC Mail Room/White Laminate Counter

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown/White	0%	100%	None Detected	

Client Sample ID: 101116BH-37A ***Lab Sample ID:*** **041631778-0076**
Sample Description: SC 2nd Floor Men's Bathroom/Yellow Laminate Counter Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016				Not Analyzed	Mastic is inseparable from laminate counter top.

Client Sample ID: 101116BH-37B ***Lab Sample ID:*** **041631778-0077**
Sample Description: SC Mail Room/Yellow Laminate Counter Glue

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-38A ***Lab Sample ID:*** **041631778-0078**
Sample Description: SC 1st Floor Kitchen Bathroom Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-38B ***Lab Sample ID:*** **041631778-0079**
Sample Description: SC 1st Floor Kitchen Bathroom Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

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Client Sample ID: 101116BH-38C ***Lab Sample ID:*** **041631778-0080**
Sample Description: SC 1st Floor Kitchen Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-38D ***Lab Sample ID:*** **041631778-0081**
Sample Description: SC 2nd Floor Women's Bathroom by Room W229 Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-38E ***Lab Sample ID:*** **041631778-0082**
Sample Description: SC 2nd Floor Women's Bathroom by Room W229 Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-38F ***Lab Sample ID:*** **041631778-0083**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229 Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-38G ***Lab Sample ID:*** **041631778-0084**
Sample Description: SC 2nd Floor Men's Bathroom by Room W229 Ceiling/White Plaster Skim Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-39A ***Lab Sample ID:*** **041631778-0085**
Sample Description: SC 1st Floor Kitchen Bathroom Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-39B ***Lab Sample ID:*** **041631778-0086**
Sample Description: SC 1st Floor Kitchen Bathroom Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-39C ***Lab Sample ID:*** **041631778-0087**
Sample Description: SC 1st Floor Kitchen Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

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Client Sample ID: 101116BH-39D ***Lab Sample ID:*** **041631778-0088**

Sample Description: SC 2nd Floor Women's Bathroom by Room W229 Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-39E ***Lab Sample ID:*** **041631778-0089**

Sample Description: SC 2nd Floor Women's Bathroom by Room W229 Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-39F ***Lab Sample ID:*** **041631778-0090**

Sample Description: SC 2nd Floor Men's Bathroom by Room W229 Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-39G ***Lab Sample ID:*** **041631778-0091**

Sample Description: SC 2nd Floor Men's Bathroom by Room W229 Ceiling/Light Gray Plaster Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-40A ***Lab Sample ID:*** **041631778-0092**

Sample Description: SC 2nd Floor Room W229/White 1"x1" Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	60%	40%	None Detected	

Client Sample ID: 101116BH-40B ***Lab Sample ID:*** **041631778-0093**

Sample Description: SC Mail Room/White 1"x1" Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Tan	80%	20%	None Detected	

Client Sample ID: 101116BH-41A ***Lab Sample ID:*** **041631778-0094**

Sample Description: SC 2nd Floor Corridor by Café/White 2"x4" Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Tan/White	80%	20%	None Detected	

Client Sample ID: 101116BH-41B ***Lab Sample ID:*** **041631778-0095**

Sample Description: SC 1st Floor Mail Room/White 2"x4" Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Tan/White	80%	20%	None Detected	

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Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-42A ***Lab Sample ID:*** **041631778-0096**

Sample Description: SC Cafeteria/White 2"x6" Type I Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Tan/White	80%	20%	None Detected	

Client Sample ID: 101116BH-42B ***Lab Sample ID:*** **041631778-0097**

Sample Description: SC Cafeteria/White 2"x6" Type I Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Tan/White	80%	20%	None Detected	

Client Sample ID: 101116BH-43A ***Lab Sample ID:*** **041631778-0098**

Sample Description: SC Cafeteria/White 2"x6" Type II Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Tan/White	80%	20%	None Detected	

Client Sample ID: 101116BH-43B ***Lab Sample ID:*** **041631778-0099**

Sample Description: SC Cafeteria/White 2"x6" Type II Ceiling Tiles

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Tan/White	80%	20%	None Detected	

Client Sample ID: 101116BH-44A ***Lab Sample ID:*** **041631778-0100**

Sample Description: SC Mail Room/Brown Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Brown	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Brown	0.0%	100%	None Detected	

Client Sample ID: 101116BH-44B ***Lab Sample ID:*** **041631778-0101**

Sample Description: SC Café/Brown Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016				Not Analyzed	Samples 44A and 44B submitted in same bag.

Client Sample ID: 101116BH-45A ***Lab Sample ID:*** **041631778-0102**

Sample Description: SC 2nd Floor Room W229/Light Yellow Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Yellow	0.0%	100%	None Detected	

Client Sample ID: 101116BH-45B ***Lab Sample ID:*** **041631778-0103**

Sample Description: SC 2nd Floor Room W229/Light Yellow Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

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Client Sample ID: 101116BH-46A ***Lab Sample ID:*** **041631778-0104**
Sample Description: SC 2nd Floor Room W229/Dark Yellow Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Yellow	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Yellow	0.0%	100%	None Detected	

Client Sample ID: 101116BH-46B ***Lab Sample ID:*** **041631778-0105**
Sample Description: SC 2nd Floor Room W229/Dark Yellow Ceiling Tiles Glue Daubs

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-47A ***Lab Sample ID:*** **041631778-0106**
Sample Description: SC Room W229/Black Window Sill

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Black	0%	100%	None Detected	

Client Sample ID: 101116BH-47B ***Lab Sample ID:*** **041631778-0107**
Sample Description: SC Café/Black Window Sill

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	100%	None Detected	

Client Sample ID: 101116BH-48A ***Lab Sample ID:*** **041631778-0108**
Sample Description: SC Room W229/Gray Window Sill Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-48B ***Lab Sample ID:*** **041631778-0109**
Sample Description: SC Café/Gray Window Sill Grout

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-49A ***Lab Sample ID:*** **041631778-0110**
Sample Description: SC Café Window/Gray Interior/Exterior Window Glazing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	97%	3% Chrysotile	

Client Sample ID: 101116BH-49B ***Lab Sample ID:*** **041631778-0111**
Sample Description: SC Room W229/Gray Interior/Exterior Window Glazing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

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Client Sample ID: 101116BH-50A ***Lab Sample ID:*** **041631778-0112**
Sample Description: SC 2nd Floor Men's Bathroom Window/White Window Glazing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	White	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	White	1.3%	98.7%	None Detected	

Client Sample ID: 101116BH-50B ***Lab Sample ID:*** **041631778-0113**
Sample Description: SC 2nd Floor Men's Bathroom Window/White Window Glazing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	White	0%	100%	None Detected	

Client Sample ID: 101116BH-51A ***Lab Sample ID:*** **041631778-0114**
Sample Description: SC Café Exterior Side C Window System/Gray Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	<1% Chrysotile	Sample coated in positive material from other caulk
TEM Grav. Reduction	11/22/2016	Gray	0.0%	100%	<0.1% Chrysotile	

Client Sample ID: 101116BH-51B ***Lab Sample ID:*** **041631778-0115**
Sample Description: SC Mail Room Exterior Window System/Gray Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	<1% Chrysotile	Sample coated in positive material from other caulk

Client Sample ID: 101116BH-52A ***Lab Sample ID:*** **041631778-0116**
Sample Description: SC Café Exterior Side C Window System/Tan Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Tan	0%	94%	6% Chrysotile	

Client Sample ID: 101116BH-52B ***Lab Sample ID:*** **041631778-0117**
Sample Description: SC Mail Room Exterior Window System/Tan Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-53A ***Lab Sample ID:*** **041631778-0118**
Sample Description: SC Cafe Exterior Window/Gray Bottom Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	92%	8% Chrysotile	

Client Sample ID: 101116BH-53B ***Lab Sample ID:*** **041631778-0119**
Sample Description: SC Kitchen/Bathroom Exterior Window/Gray Bottom Exterior Window Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

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Client Sample ID: 101116BH-54A ***Lab Sample ID:*** **041631778-0120**
Sample Description: SC Cafeteria Exterior Door 12/Gray Exterior Door Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray/Red	0%	95%	5% Chrysotile	

Client Sample ID: 101116BH-54B ***Lab Sample ID:*** **041631778-0121**
Sample Description: SC Kitchen Exterior Door/Gray Exterior Door Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-55A ***Lab Sample ID:*** **041631778-0122**
Sample Description: SC Exterior Door 12/Gray Door Soffit Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-55B ***Lab Sample ID:*** **041631778-0123**
Sample Description: SC Exterior Door 12/Gray Door Soffit Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/19/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-55C ***Lab Sample ID:*** **041631778-0124**
Sample Description: SC Exterior Door 12/Gray Door Soffit Rough Coat

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-56A ***Lab Sample ID:*** **041631778-0125**
Sample Description: SC Café Exterior Vent Side D Wall/Gray Exterior Vent Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	5%	95%	None Detected	
TEM Grav. Reduction	11/22/2016	Gray	0.0%	100%	None Detected	

Client Sample ID: 101116BH-56B ***Lab Sample ID:*** **041631778-0126**
Sample Description: SC Café Exterior Vent Side D Wall/Gray Exterior Vent Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	5%	95%	None Detected	

Client Sample ID: 101116BH-57A ***Lab Sample ID:*** **041631778-0127**
Sample Description: SC Exterior Side C Foundation/Brick Wall Union/Gray Foundation/Brick Wall Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

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Client Sample ID: 101116BH-57B ***Lab Sample ID:*** **041631778-0128**
Sample Description: SC Exterior Side C Foundation/Brick Wall Union/Gray Foundation/Brick Wall Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray/Tan	0%	98%	2% Chrysotile	The sample group is not homogeneous.

Client Sample ID: 101116BH-58A ***Lab Sample ID:*** **041631778-0129**
Sample Description: SC Café Exterior Foundation Wall Side D Wall/Gray Foundation Wall

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-58B ***Lab Sample ID:*** **041631778-0130**
Sample Description: SC Café Exterior Foundation Wall Side C Wall/Gray Foundation Wall

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-59A ***Lab Sample ID:*** **041631778-0131**
Sample Description: SC Café Exterior Side D Wall/Terracotta Brick

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Red	0%	100%	None Detected	

Client Sample ID: 101116BH-59B ***Lab Sample ID:*** **041631778-0132**
Sample Description: SC Café Exterior Side D Wall/Terracotta Brick

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Red	0%	100%	None Detected	

Client Sample ID: 101116BH-60A ***Lab Sample ID:*** **041631778-0133**
Sample Description: SC Café Exterior Side D Wall/Gray Brick Rough

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-60B ***Lab Sample ID:*** **041631778-0134**
Sample Description: SC Café Exterior Side D Wall/Gray Brick Rough

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	100%	None Detected	

Client Sample ID: 101116BH-61A ***Lab Sample ID:*** **041631778-0135**
Sample Description: SC Café Exterior Side D behind Brick/Black Tar/Metal Flashing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

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Client Sample ID: 101116BH-61B ***Lab Sample ID:*** **041631778-0136**
Sample Description: SC Café Exterior Side D behind Brick/Black Tar/Metal Flashing

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	100%	None Detected	

Client Sample ID: 101116BH-62A ***Lab Sample ID:*** **041631778-0137**
Sample Description: SC Café Exterior Side D Wall/Gray Expansion Wall Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	96%	4% Chrysotile	

Client Sample ID: 101116BH-62B ***Lab Sample ID:*** **041631778-0138**
Sample Description: SC Exterior Roof Wall by Room W229/Women' Bath/Gray Expansion Wall Caulking

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016			Positive Stop (Not Analyzed)		

Client Sample ID: 101116BH-63A ***Lab Sample ID:*** **041631778-0139**
Sample Description: SC Exterior Soffit by W229 Room/Gray Cementitious Soffit

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	85%	15% Chrysotile	

Client Sample ID: 101116BH-63B ***Lab Sample ID:*** **041631778-0140**
Sample Description: SC Exterior Soffit by W229 Room/Gray Cementitious Soffit

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016			Positive Stop (Not Analyzed)		

Client Sample ID: 101116BH-64A ***Lab Sample ID:*** **041631778-0141**
Sample Description: SC Upper Roof (Roof 1)/Tan Caulking on Metal Fascia

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Gray	0%	96%	4% Chrysotile	

Client Sample ID: 101116BH-64B ***Lab Sample ID:*** **041631778-0142**
Sample Description: SC Upper Roof (Roof 1)/Tan Caulking on Metal Fascia

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016			Positive Stop (Not Analyzed)		

Client Sample ID: 101116BH-65A ***Lab Sample ID:*** **041631778-0143**
Sample Description: SC Upper Roof (Roof 1) Field Top Layer/Black Modified Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

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Client Sample ID: 101116BH-65B ***Lab Sample ID:*** **041631778-0144**
Sample Description: SC Upper Roof (Roof 1) Field Top Layer/Black Modified Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: 101116BH-66A ***Lab Sample ID:*** **041631778-0145**
Sample Description: SC Upper Roof (Roof 1) Field 2nd Layer/Yellow Foam Roof Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black/Yellow	10%	90%	None Detected	

Client Sample ID: 101116BH-66B ***Lab Sample ID:*** **041631778-0146**
Sample Description: SC Upper Roof (Roof 1) Field 2nd Layer/Yellow Foam Roof Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black/Yellow	10%	90%	None Detected	

Client Sample ID: 101116BH-67A ***Lab Sample ID:*** **041631778-0147**
Sample Description: SC Upper Roof (Roof 1) Field 3rd Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-67B ***Lab Sample ID:*** **041631778-0148**
Sample Description: SC Upper Roof (Roof 1) Field 3rd Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: 101116BH-68A ***Lab Sample ID:*** **041631778-0149**
Sample Description: SC Upper Roof (Roof 1) Field 4th Layer/Brown Wood Comprised Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	98%	2%	None Detected	

Client Sample ID: 101116BH-68B ***Lab Sample ID:*** **041631778-0150**
Sample Description: SC Upper Roof (Roof 1) Field 5th Layer/Brown Wood Comprised Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	90%	10%	None Detected	

Client Sample ID: 101116BH-69A ***Lab Sample ID:*** **041631778-0151**
Sample Description: SC Upper Roof (Roof 1) Field Bottom Layer/Black Base Roof Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	10%	90%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

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Client Sample ID: 101116BH-69B ***Lab Sample ID:*** **041631778-0152**
Sample Description: SC Upper Roof (Roof 1) Field Bottom Layer/Black Base Roof Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	10%	90%	None Detected	

Client Sample ID: 101116BH-70A ***Lab Sample ID:*** **041631778-0153**
Sample Description: SC Upper Roof (Roof 1) Edge Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	

Client Sample ID: 101116BH-70B ***Lab Sample ID:*** **041631778-0154**
Sample Description: SC Upper Roof (Roof 1) Edge Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown/Black	30%	65%	**5% Chrysotile**	Sample is non-homogeneous.

Client Sample ID: 101116BH-71A ***Lab Sample ID:*** **041631778-0155**
Sample Description: SC Upper Roof (Roof 1) Edge 3rd Layer/Black Pitch Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	85%	**15% Chrysotile**	

Client Sample ID: 101116BH-71B ***Lab Sample ID:*** **041631778-0156**
Sample Description: SC Upper Roof (Roof 1) Edge 3rd Layer/Black Pitch Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-72A ***Lab Sample ID:*** **041631778-0157**
Sample Description: SC Upper Roof (Roof 1) Edge 4th Layer/Black Roof Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-72B ***Lab Sample ID:*** **041631778-0158**
Sample Description: SC Upper Roof (Roof 1) Edge 4th Layer/Black Roof Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	

Client Sample ID: 101116BH-73A ***Lab Sample ID:*** **041631778-0159**
Sample Description: SC Upper Roof (Roof 1) Edge Bottom Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	90%	**10% Chrysotile**	

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Client Sample ID: 101116BH-73B ***Lab Sample ID:*** **041631778-0160**
Sample Description: SC Upper Roof (Roof 1) Edge Bottom Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016			Positive Stop (Not Analyzed)		

Client Sample ID: 101116BH-74A ***Lab Sample ID:*** **041631778-0161**
Sample Description: SC Upper Roof (Roof 1) on Lighting Rod/Black Pitch Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	100%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-74B ***Lab Sample ID:*** **041631778-0162**
Sample Description: SC Upper Roof (Roof 1) on Lighting Rod/Black Pitch Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	100%	None Detected	

Client Sample ID: 101116BH-75A ***Lab Sample ID:*** **041631778-0163**
Sample Description: SC Upper Roof (Roof 1) Penetration Top Layer/Black Roof Penetration Flashing Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black/Silver	0%	92%	**8% Chrysotile**	Inseparable silver paint

Client Sample ID: 101116BH-75B ***Lab Sample ID:*** **041631778-0164**
Sample Description: SC Upper Roof (Roof 1) Penetration Top Layer/Black Roof Penetration Flashing Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016			Positive Stop (Not Analyzed)		

Client Sample ID: 101116BH-76A ***Lab Sample ID:*** **041631778-0165**
Sample Description: SC Upper Roof (Roof 1) Penetration 3rd Layer/Black Roof Penetration Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	**<0.1% Chrysotile**	

Client Sample ID: 101116BH-76B ***Lab Sample ID:*** **041631778-0166**
Sample Description: SC Upper Roof (Roof 1) Penetration 3rd Layer/Black Roof Penetration Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: 101116BH-77A ***Lab Sample ID:*** **041631778-0167**
Sample Description: SC Upper Roof (Roof 1) Penetration 5th Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	0%	75%	**25% Chrysotile**	

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Client Sample ID: 101116BH-77B ***Lab Sample ID:*** **041631778-0168**
Sample Description: SC Upper Roof (Roof 1) Penetration 5th Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-78A ***Lab Sample ID:*** **041631778-0169**
Sample Description: SC Upper Roof (Roof 1) Penetration Bottom Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-78B ***Lab Sample ID:*** **041631778-0170**
Sample Description: SC Upper Roof (Roof 1) Penetration Bottom Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	25%	75%	None Detected	

Client Sample ID: 101116BH-79A ***Lab Sample ID:*** **041631778-0171**
Sample Description: SC Lower Roof (Roof 2) Field Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	25%	75%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-79B ***Lab Sample ID:*** **041631778-0172**
Sample Description: SC Lower Roof (Roof 4) Field Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	27%	73%	None Detected	

Client Sample ID: 101116BH-80A ***Lab Sample ID:*** **041631778-0173**
Sample Description: SC Lower Roof (Roof 2) Field 2nd Layer/Yellow Foam Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black/Yellow	0%	100%	None Detected	Attached tar included in result

Client Sample ID: 101116BH-80B ***Lab Sample ID:*** **041631778-0174**
Sample Description: SC Lower Roof (Roof 3) Perimeter 2nd Layer/Yellow Foam Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Yellow	0%	100%	None Detected	

Client Sample ID: 101116BH-81A ***Lab Sample ID:*** **041631778-0175**
Sample Description: SC Lower Roof (Roof 2) Field 3rd Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

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Client Sample ID: 101116BH-81B ***Lab Sample ID:*** **041631778-0176**
Sample Description: SC Lower Roof (Roof 4) Field 3rd Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	20%	80%	None Detected	

Client Sample ID: 101116BH-82A ***Lab Sample ID:*** **041631778-0177**
Sample Description: SC Lower Roof (Roof 2) Field 4th Layer/Brown Wood Comprised Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	80%	20%	None Detected	

Client Sample ID: 101116BH-82B ***Lab Sample ID:*** **041631778-0178**
Sample Description: SC Lower Roof (Roof 3) Perimeter 4th Layer/Brown Wood Comprised Insulation

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	90%	10%	None Detected	

Client Sample ID: 101116BH-83A ***Lab Sample ID:*** **041631778-0179**
Sample Description: SC Lower Roof (Roof 2) Field 5th Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown/Black	40%	60%	None Detected	
TEM Grav. Reduction	11/22/2016	Brown/Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-83B ***Lab Sample ID:*** **041631778-0180**
Sample Description: SC Lower Roof (Roof 4) Field 5th Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: 101116BH-84A ***Lab Sample ID:*** **041631778-0181**
Sample Description: SC Lower Roof (Roof 2) Edge Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	25%	72%	**3% Chrysotile**	

Client Sample ID: 101116BH-84B ***Lab Sample ID:*** **041631778-0182**
Sample Description: SC Lower Roof (Roof 3) Edge Top Layer/Black Roof Build Up

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-85A ***Lab Sample ID:*** **041631778-0183**
Sample Description: SC Lower Roof (Roof 2) Edge 3rd Layer/Black Roof Build Up 2nd Layer

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Asbestos Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	67%	**3% Chrysotile**	

EMSL Analytical, Inc.
200 Route 130 North Cinnaminson, NJ 08077
Phone/Fax: (800) 220-3675 / (856) 786-5974
http://www.EMSL.com / cinnasblab@EMSL.com

EMSL Order ID:	041631778
Customer ID:	ENVI54
Customer PO:	20070369.A9E
Project ID:	

Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Client Sample ID: 101116BH-85B ***Lab Sample ID:*** **041631778-0184**
Sample Description: SC Lower Roof (Roof 3) Edge 3rd Layer/Black Roof Build Up 2nd Layer

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016				Positive Stop (Not Analyzed)	

Client Sample ID: 101116BH-86A ***Lab Sample ID:*** **041631778-0185**
Sample Description: SC Lower Roof (Roof 2) Edge 5th Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	35%	65%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-86B ***Lab Sample ID:*** **041631778-0186**
Sample Description: SC Lower Roof (Roof 3) Edge 5th Layer/Black Roof Base Sheet

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: 101116BH-87A ***Lab Sample ID:*** **041631778-0187**
Sample Description: SC Lower Roof (Roof 2) Pitch Pocket/Black Roof Pitched Pocket Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	35%	65%	None Detected	
TEM Grav. Reduction	11/22/2016	Black	0.0%	100%	None Detected	

Client Sample ID: 101116BH-87B ***Lab Sample ID:*** **041631778-0188**
Sample Description: SC Lower Roof (Roof 2) Pitch Pocket/Black Roof Pitched Pocket Tar

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Black	30%	70%	None Detected	

Client Sample ID: Cafe ***Lab Sample ID:*** **041631778-0189**
Sample Description:

TEST	Analyzed Date	Color	Non-Asbestos Fibrous	Non-Fibrous	Asbestos	Comment
PLM	11/20/2016	Brown	0%	100%	None Detected	Sample labeled brown G/D on SR Ceiling.

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http://www.EMSL.com / cinnasblab@EMSL.com

EMSL Order ID:	041631778
Customer ID:	ENVI54
Customer PO:	20070369.A9E
Project ID:	

Summary Test Report for Asbestos Analysis of Bulk Material via EPA 600/R-93/116

Analyst(s):

Benjamin Verghese	PLM (40)
Brett Polumbo	PLM (34)
Chelsey Bilhear	PLM (10)
Christian Strey	PLM (5)
Daniel Fricker	PLM (31)
Megan Wierzbowski	PLM (41)
Rebecca Siegel	PLM (9)
Ted Young	TEM Grav. Reduction (1)
William Nguyen	TEM Grav. Reduction (28)

Reviewed and approved by:

Benjamin Ellis, Laboratory Manager
or Other Approved Signatory

EMSL maintains liability limited to cost of analysis. This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. This test report must not be used to claim product endorsement by NVLAP or any agency of the U.S. Government. EMSL bears no responsibility for sample collection activities or analytical method limitations. The laboratory is not responsible for the accuracy of results when requested to physically separate and analyze layered samples. PLM alone is not consistently reliable in detecting asbestos in floor coverings and similar NOBs

Samples analyzed by EMSL Analytical, Inc. Cinnaminson, NJ NVLAP Lab Code 101048-0, AIHA-LAP, LLC-IHLAP Lab 100194, NYS ELAP 10872, NJ DEP 03036

Initial report from: 11/21/201606:51:35

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Appendix E

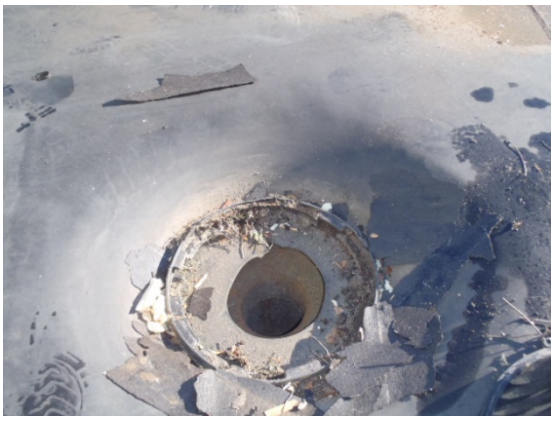
Site Photographs

Theatre Roof – ACM Cementitious Roof Shingles on Adjacent Pitch Roof

Theatre Roof – ACM Black Roof Drain Caulking

Theatre Roof – Loose ACM Black Roofing Paper Debris from Adjacent Roof System

Student Center – Upper Roof (1) ACM Black Layered Roofing at Edge



Theatre Roof – Roof Drain with ACM Black/Gray Caulking

Student Center – Lower Roof (2) ACM Black Layered Roofing at Edge

Student Center – Upper Roof (1) ACM Cementitious Soffit Paneling

Student Center – ACM Mudded Pipe Fitting Insulation above Suspended Ceiling in Corridor Adjacent to Dining Hall

Student Center –ACM Gray Exterior Expansion Caulking

Student Center –Exterior Window System with ACM Interior/Exterior Window Glazing and Tan Window Caulking

Student Center – Exterior Door with ACM Gray Exterior Door Caulking

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Appendix F

Lead Paint Determination Field Data Sheet

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146 Hartford Road, Manchester, CT 06040

(860) 646-2469 Fax (860) 649-6883

XRF LEAD SCREENING FIELD DATA SHEET

Inspector Name: John Hobbins/Sandra Guzman **Inspector License #:** 2156/2210

Date: 10/11/2016 **XRF Model:** LPA **Serial :** RMD3241R

Project Name: Norwalk Community College Phase III Renovation **Project Number:** 20070639.A9E

Address: 188 Richards Avenue, Norwalk CT **Project PM:** Miguel Marques

XRF Calibration Check-RMD (0.7 to 1.3 mg/cm² inclusive)

	Hour	First Reading	Second Reading	Third Reading	Average
First Check	1136	1.1	1.0	1.1	1.06
Second Check	1545	1.0	1.2	1.1	1.10
Third Check	1730	0.9	0.9	1.2	1.0
Fourth Check					

Side	Surface/Component	Substrate	Color	XRF Reading	Positive (√)	Comments/Notes
	Theater 2nd Fl					
B	Wall	Concrete	Beige	-0.1		Theater 2nd Fl
B	Door	Metal	Green	-0.1		
B	D. Trim	"	Green	-0.1		
D	Jamb	"	Green	-0.2		
D	Wall	Sheetrock	Beige	-0.1		
C	Wall	"	Beige	-0.3		
C	Window Sill	Metal	Black	-0.3		
C	" Sash	"	Black	-0.2		
C	" Frame	Metal	Black	-0.2		
	Theater 1st Floor					Theater 1st Fl
A	Wall	Concrete	Beige	-0.1		
A	Door	Metal	Red	-0.0		
A	D Frame	Metal	Red	-0.3		
A	Jamb	Metal	Red	-0.0		
—	Floor	Concrete	Gray	-0.3		
D	Wall	Conc/Block	Black	-0.1		
D	Door	Metal	Black	-0.1		
	D Trim	X	Black	-0.1		

* Substrate Type: Metal = M, Wood = W, Plaster = P, Sheetrock = S, Concrete = C, Brick = B

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XRF LEAD SCREENING FIELD DATA SHEET (CONT.)

Project Name: Norwalk Community College Phase III Renovation **Project Number:** 20070639.A9E

Address: 188 Richards Avenue, Norwalk CT **Project PM:** Miguel Marques

Side	Surface/Component	Substrate	Color	XRF Reading	Positive (√)	Comments/Notes
C	Window. Frame.	Metal.	Black.	-0.2		Theater Exterior
C	" Sash.	Metal.	Black	-0.7		"
C	Sill.	Metal.	Black	0.5		"
C	Door	Metal	Red	-0.1		Door 14
C	" Trim	Metal	Red	-0.1		"
C	Stair Hand Rail	Metal.	Red.	-0.1		Stair by Door 15

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XRF LEAD SCREENING FIELD DATA SHEET (CONT.)

Project Name: Norwalk Community College Phase III Renovation **Project Number:** 20070639.A9E

Address: 188 Richards Avenue, Norwalk CT **Project PM:** Miguel Marques

Side	Surface/Component	Substrate	Color	XRF Reading	Positive (√)	Comments/Notes
A	Wall.	Concrete Blo	Gray	-0.1		Student Cente 2nd flor
A	Window door Trim.	Windo Metal Trim	White	-0 3		"
A	D Frame	Metal	White	-0.3.		"
A	Jamb	Metal	White	0.3		"
A	Window Frame.	"	White	-0.4		"
A	Sash.	"	"	-0.9.		"
C	Radiator.	Metal.	Gray	-0.2.		"
C	Steel Column.	Steel	White.	0.2		"
	Wall.	C. Block.	White	0.1		"
C.	W Trim.	Metal.	White.	-0.7		"
C	M Column.	"	White	0.3		"
A	Wall.	Ceramic	Green	-0.2.		"
A	Door Frame	Metal -	White	0.6.		"
A	D Jamb.	Metal	White	-0.6		"
B.	Wall,	Con. Block	Green.	0.0.		Student Center 1st Flr
B	Window Trim.	-Metal	Green	-0.1		Bathroom
A	Window Sash.	Metal	Green	-0.3		"
D	Radiator	Metal	"	0.2.		"
C	Door Frame	Metal	"	0.3.		"
C	Door Sash.	Metal.	"	0.3		"
D	Shelf	Metal.	Black	-0.0		
D	Shelf Support	Metal	Black	-0.0.		
C	Door Trim.	"	White	-0.1.		
C	D. Jamb	Metal	White.	-0.6		
D	Wall	Sheetrock.	Beige.	-0.1.		Cafeteria
D	Window Frame.	Metal	Gray/Blue	-0.3		
A	Sill	Stone.	Gray/Blue	-0.1		

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XRF LEAD SCREENING FIELD DATA SHEET (CONT.)

Project Name: Norwalk Community College Phase III Renovation **Project Number:** 20070639.A9E

Address: 188 Richards Avenue, Norwalk CT **Project PM:** Miguel Marques

Side	Surface/Component	Substrate	Color	XRF Reading	Positive (√)	Comments/Notes
D	Stair Rail	Wood	Gray/Blue	-0.1		Cafe
D	Radiator	Metal	" "	-0.2		"
D	Column	Steel	" "	-0.1		"
B	Door Window	Metal	Gray/Blue	-0.2		"
B	Trim	"	Gray/Blue	-0.0		"
B	Jamb	"	Gray/Blue	-0.2		"
C	Door	Metal	Tan	-0.3		Corridor
C	Door Frame	"	"	-0.2		"
C	Wall	Glazed Block	"	-0.1		"
A	Wall		Beige	-0.1		Mail Room
A	Steel Column	Steel Column	White	-0.3		"
A	Conc Base	Glazed Block CB	Black	0.1		"
D	Window Frame	Metal	Tan	-0.1		Corridor Window
	" Sash	Metal	Tan	-0.2		"
C	Wall	Concrete Wall	"	-0.2		"
B	Door Window	Metal	L Gray	-0.0		Exterior Cafe Door #2
B	" Trim	"	L Gray	-0.2		
B	" Jamb	"	L Gray	-0.1		
D	Door	Metal	Gray	0.2		Exterior Kitchen Door
D	Trim	Metal	Gray	-0.0		"
D	Support Column	Metal	Red	-0.0		"
D	Stair Handrail	Metal	Red	0.6		"

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XRF LEAD SCREENING FIELD DATA SHEET (CONT.)

Project Name: Norwalk Community College Phase III Renovation **Project Number:** 20070639.A9E

Address: 188 Richards Avenue, Norwalk CT **Project PM:** Miguel Marques

Side	Surface/Component	Substrate	Color	XRF Reading	Positive (√)	Comments/Notes
D	Door Jamb	Metal	Black	-0.3		
D	Concrete Block Wall	Concrete Wall	Gray	-0.1		Control
C	Door Corridor	Metal	Green	-0.0		4
C	D Trim	Metal	Green	0.3		4
C	D - Jamb	Metal	Green	-0.0		4
C	Window Trim	Metal	Black	-0.4		4
C	n Sash	Metal	Black	-0.5		4

* Substrate Type: Metal = M, Wood = W, Plaster = P, Sheetrock = S, Concrete = C, Brick = B
N/A: Not Accessible; N/C: Not Coated; COV: Covered; VR – Vinyl Replacement

Section 50 40 00
Subsurface Geotechnical Report

FUSS & O'NEILL

M E M O R A N D U M

TO: John Doherty, A.I.A., Partner
Mitchell Giurgola Architects, LLP

FROM: Christopher J. Cullen, P.E., Senior Project Manager
Andrea C. Judge, P.E., Project Engineer
Fuss & O'Neill, Inc.

DATE: December 15, 2015

RE: Foundation Design Recommendations
Proposed Pedestrian Bridge and Building Additions
Norwalk Community College
Norwalk, Connecticut

This memorandum summarizes Fuss & O'Neill, Inc.'s (Fuss & O'Neill) findings from a geotechnical engineering study completed for the proposed improvements to the Norwalk Community College Campus in Norwalk, Connecticut.

The contents of this memorandum are subject to the attached limitations.

Objectives and Scope of Services

The objectives of Fuss & O'Neill's work were to assess the subsurface conditions at the proposed location of the new building additions and provide recommendations for foundation design and construction. To achieve the objectives of the project, Fuss & O'Neill completed the following scope of work:

- Drilling eight (8) soil borings and collecting soil and rock core samples,
- Performing engineering analysis to evaluate the proposed bearing capacity and seismic site classification
- Developing design and construction recommendations, and
- Preparing this Geotechnical Memorandum.

Fuss & O'Neill understands that the proposed improvements include the following components:

- The construction of a pedestrian bridge between the buildings located on the east and west sides of Richards Avenue (Herein referred to as the East and West Campuses, respectively).
- The construction of an approximately 6,000 square foot addition to the northwest side of the West Campus for a proposed Student Center.
- There will be approximately 12 to 18 feet of compacted fill placed within the proposed student center building footprint.
- The construction of an addition to the existing theater on the east side of the East Campus.

Existing Site Conditions

The following summarizes the existing conditions at the subject sites.

Student Center: The proposed student center is to abut the northwest corner of the existing west campus building. The grades within the area of the proposed student center decrease from elevation 94 feet adjacent to the west side of the existing building for approximately 30 feet to meet the presumed natural grade at elevation 86 feet. Beyond the noted area of fill, the existing grade in the proposed expansion footprint is approximately elevation 86 feet. The surface treatment consists of grass with concrete pathways.

Theater Expansion: The theater expansion is proposed to be constructed at the northwest side of the west campus. The existing grades are generally flat varying from elevation 101 to 100 feet. The surface treatment in the area of the proposed expansion generally consists of grassed or mulched landscaped areas or concrete sidewalks.

Pedestrian Bridge: The proposed pedestrian bridge is to cross Richards Avenue and bear adjacent to the East and West Campuses. The existing ground surface at the proposed west abutment consists of a flat grassed area with a concrete pathway near elevation 91 feet. The existing ground surface at the proposed east abutment consists of a grassed area sloping upward in grade from west to east from approximately elevation 94 to 100 feet due to apparent area of fill. A drainage structure at elevation 95.7 feet was noted to have a chamber invert of approximately 13 feet below the rim.

Subsurface Exploration Program

A subsurface exploration program was completed at the site consisting of eight (8) soil borings.

Borings were completed by Clarence Welti Associates, Inc. of Glastonbury, Connecticut under subcontract to Fuss & O'Neill, Inc. Test borings were completed on November 5 and 6, 2015 utilizing a truck-mounted drill rig and standard solid stem auger techniques.

The following table summarizes the borings that were completed and their general locations. Please refer to the attached Boring Location Plan for the locations of the borings.

Boring Number	Proposed Improvement Areas
B-1	Student Center Expansion
B-2	
B-3	
B-4	Pedestrian Bridge

Boring Number	Proposed Improvement Areas
B-5	
B-6	
B-7	Theater Expansion
B-8	

Split spoon soil samples were obtained at maximum 5-foot intervals using the Standard Penetration Test (SPT) per ASTM D-1586. The SPT consists of driving a 2-inch outside-diameter split spoon sampler 24 inches with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler from 6 to 18 inches is the Standard Penetration Resistance, also known as the SPT N-value, which is a relative indicator of the in-place soil density or consistency. Fuss & O'Neill personnel observed and logged the borings. The logs of the soil borings are included in Appendix A and their locations are indicated on the attached figures provided by Mitchell Giurgola.

Laboratory Testing

Laboratory testing included particle size determinations on selected representative samples. The results of the testing are attached.

Subsurface Profile

Subsurface conditions in the proposed improvement areas are generally described as follows:

Student Center Addition

The subsurface profile consists of approximately 4 inches of loam overlying a layer of brown medium dense sandy subsoil, overlying a deposit of native, undisturbed Sand, overlying Weathered Rock and/or Boulders/Cobbles.

Subsoil: a 5 foot deep layer of sandy subsoil was encountered at borings B-1 and B-2 comprised of moist, brown, fine to medium SAND, with and-to-some amounts of inorganic silt, some-to-little gravel, trace organics. Based on the SPT N-values, the relative density of the subsoil is medium dense.

Sand: An approximately 6-foot thick layer of virgin (native and undisturbed) brown to tan fine to medium SAND with little to some silt, and little gravel was encountered underlying the Subsoil at boring B-1 and B-2, and underlying the loam at boring B-3. Based on the SPT N-values, the relative density of the Sand is medium dense to very dense.

Weathered Rock and/or Boulders/Cobbles: Borings B-1 through B-3 were terminated within Weathered Rock and/or Boulders/Cobbles at depths of 11 feet, 11.5 feet, and 8.5 feet, respectively. A rock core was attempted to confirm the presence of bedrock at boring B-3. The rock that was recovered during the core consisted of a series of rounded weathered rocks apparently of varying mineral composition and did not appear consistent with competent bedrock.

Based on visual observations at the site, there appears to be fill placed adjacent to the existing building. In general, the fill is not likely suitable to support the proposed foundation and site features in its current condition. It is not known if the fill was placed in a controlled manner and the material may be of varying or inadequate relative density.

Groundwater was not encountered in the Student Center borings.

Pedestrian Bridge

West Campus:

Fill: Fill was encountered underlying the surface treatment to a depth of 4.5 to 4 feet at borings B-4 and B-5. The Fill consisted of moist, brown, fine GRAVEL, and fine to medium sand, with little inorganic silt. Based on the SPT N-values, the relative density of the Fill is very dense.

Silty sand: An approximately 9-foot thick layer of virgin (native and undisturbed) brown silty sand was encountered underlying the fill. The silty sand consisted of moist, brown SAND, with some silt and trace fine gravel. Based on the SPT N-values, the relative density of the silty sand is medium dense. Auger refusal was encountered at depths of 4.5 feet (B-4) and 13 feet below the existing ground surface (B-5). Further probing was not attempted at boring B-4 due to the potential for conflicts with nearby buried drainage structures. Therefore, the auger refusal at boring B-4 is considered inconclusive with regard to the presence of bedrock.

East Campus:

Fill: Fill was encountered underlying the surface treatment to a depth of 2 feet at boring B-6. The Fill consisted of moist, brown, fine to medium SAND and SILT, trace gravel. Based on the SPT N-values, the relative density of the Fill is very loose to loose.

In general, the fill is not likely suitable to support the proposed foundation and site features in its current condition. It is not known if the fill was placed in a controlled manner and the material may be of varying or inadequate relative density.

Silt: An approximately 7.5-foot thick layer of virgin (native and undisturbed) brown silt was encountered underlying the Fill. The silt deposit consisted of moist, brown, non-plastic SILT, with little fine sand, trace fine gravel. Based on the SPT N-values, the relative density of the silt is loose.

Sand: An approximately 6-foot thick layer of virgin (native and undisturbed) brown to tan fine to medium SAND with little to some silt, and little gravel was encountered underlying the silt. Based on the SPT N-values, the relative density of the sand is medium dense.

The soil boring completed at the east side of the pedestrian bridge was terminated at 8.5 feet below the ground surface due to auger refusal.

Groundwater was not encountered in the Pedestrian Bridge borings.

Theater Addition

Fill: Fill was encountered underlying the surface treatment to a depth of 1 to 1.5 feet at borings B-7 and B-8. The fill consisted of moist, brown, fine to medium SAND, little silt, little gravel, trace brick fragments. Based on the SPT N-values, the relative density of the Fill is medium dense to dense.

In general, the fill is not likely suitable to support the proposed foundation and site features in its current condition. It is not known if the fill was placed in a controlled manner and the material may be of varying or inadequate relative density.

Weathered Rock and/or Boulders/Cobbles: Borings B-7 and B-8 were terminated with auger refusal within the Weathered Rock and/or Boulders/Cobbles at depths of 4 feet and 7.5 feet, respectively.

Groundwater was not encountered in the Theater Addition borings.

Foundation Design Recommendations

Upon review of the subsurface data collected during our boring program, the following recommendations may be applied to this location for the foundation design for proposed building addition.

- Results of SPTs indicated the materials existing below the probable footing depth are generally dense to very dense and therefore should be suitable for support of the proposed building addition with conventional shallow spread footings.

- It is recommended that the foundations bear on the undisturbed Sand, Silty Sand, Silt, or Weathered Rock and/or Boulders/Cobbles deposits, or on compacted Structural Fill placed on the undisturbed soil deposits listed above.

- The recommended net allowable bearing pressure for the proposed pedestrian bridge, theater and student center expansions is 4,000 psf.

- For foundations smaller than 3 feet in their least lateral dimension, the design bearing pressures should be one-third (1/3) of the allowable bearing pressure multiplied by the least lateral dimension in feet.

- Strip footings should be no smaller than 20 inches in width, and isolated footings should be at least 3 feet wide. Place the bottom of interior footings at least 18 inches below the underside of the floor slab. For frost protection, place exterior footings and interior footings in unheated areas at least 3.5 feet below grade.

- If the bedrock surface is encountered at depths less than twelve inches below proposed footing elevations, we recommend that the bedrock be over excavated by a minimum of twelve inches and backfilled to bottom of footing elevations with structural fill. The structural fill should be compacted to at least 95 percent of its maximum dry density as determined by ASTM D 1557, Method C. Structural Fill should conform to the gradation requirements of the State of Connecticut Standard Specifications for Roads, Bridges, and Incidental Construction, Form 816 (Form 816).

Seismic Site Class and Liquefaction Potential

In general, the soils encountered at this project location consist of medium dense to very dense in-situ sands and gravels above the groundwater table. This type of condition is not considered susceptible to liquefaction.

The International Building Code Seismic Site Class is C (N>50 blows/foot).

Site Preparation Recommendations

The location of the proposed structures should be cleared of the vegetation, with root systems grubbed, and the topsoil stripped for reuse. Construction debris from demolished roadways or structures should be removed and properly disposed of, and any existing Fill underlying proposed footing locations should be excavated and removed and replaced with compacted General Fill to 3 feet below the base of footings and slabs, where applicable, and Structural fill within the 3 feet directly below structures and slabs.

After rough grades have been established, but before placement of compacted fill material, exposed surfaces should be visually inspected and probed. Frozen, wet, or loose soils and other undesirable materials should be removed. The exposed subgrade should be proof rolled with a minimum of 4 passes of a 10,000-pound static weight roller to identify loose or soft pockets that may be present and provide a firm surface for placement of fill.

In areas to be cut, the cut should extend to a minimum of 12 inches below the bottom of wall footings and floor slab and be backfilled with a 12-inch layer of compacted Structural Fill. Should the exposed subgrade conform to the gradation for Structural Fill, over-excavation is not required and the area can be proof rolled with 10 passes of a vibratory drum roller.

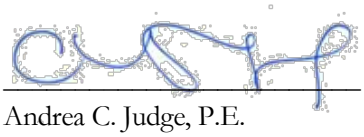
Fill materials should consist of hard, durable, sand and gravel and should be free from ice and snow, roots, sod, rubbish, and other deleterious or organic matter.

"Structural Fill" should be material conforming to Item M.02.06 and meet Grading "C" as indicated within Form 816.

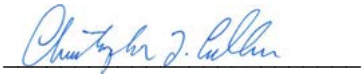
Recommended Minimum Compaction Requirements	
Proposed improvement areas	**Percent of Maximum Dry Density (ASTM D 1557)**
Structural fill below footings and below approach and structure slabs	95
General Fill for raises in grade beneath structures	92
Backfill within landscaped areas	85

Quality Control

It is recommended that Fuss & O'Neill be given the opportunity to review the final design plans and specifications to observe that that our recommendations have been implemented as we intended. Fuss & O'Neill appreciates the opportunity to assist you with this project. Should you have any questions regarding the contents of this memorandum or any other issues that may arise, please call the undersigned.



Andrea C. Judge, P.E.
Project Engineer



Christopher J. Cullen, P.E.
Senior Project Manager

Attachments: Limitations
Boring Location Plans
Test Boring Logs
Laboratory Test Results

FUSS & O'NEILL

Limitations

Foundation Design Recommendations
Proposed Pedestrian Bridge and Building Additions
Norwalk Community College, Norwalk, Connecticut

Explorations

1. The analyses and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the boring logs.

3. Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made.

Review

4. In the event that any changes in the nature, design or location of the proposed building are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by Fuss & O'Neill, Inc. It is recommended that this firm be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

Construction

5. It is recommended that this firm be retained to provide soil engineering services during construction of the excavation and foundation phases of the work. This is to observe compliance with the design concepts, specifications, and recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to start of construction.

FUSS & O'NEILL

Limitations

Foundation Design Recommendations
Proposed Pedestrian Bridge and Building Additions
Norwalk Community College, Norwalk, Connecticut

Use of Report

6. This report has been prepared for the exclusive use of Mitchell Giurgola, Architects, LLP for specific application to the proposed additions to the Norwalk Community College located in Norwalk, Connecticut in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.

7. This soil and foundation engineering report has been prepared for this project by Fuss& O'Neill. This report is for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.

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Section 50 60 00
FM Global Checklist for Roofing Systems

SAMPLE FM GLOBAL CHECKLIST FOR ROOFING SYSTEMS – page 1

CHECKLIST FOR ROOFING SYSTEM

CONTACT INFORMATION: **INDEX NUMBER:**

ROOFING CONTRACTOR (NAME & ADDRESS)	TELEPHONE NO.:	FAX:
	E-MAIL ADDRESS:	CONTACT:
CLIENT (NAME & ADDRESS)	TELEPHONE NO.:	FAX:
	E-MAIL ADDRESS:	CONTACT:

OVERVIEW OF WORK: *(Submit 1 form per roof area)*

Building Name & Number:		
Building Dimensions: Length: *ft/m;*	Width: *ft/m.;*	Height *ft/m.*
Roof Slope:		
Parapet Height ,max *(in./m)*:	Parapet Height ,min *(in./m)*:	
Type of Work: ☐ New Construction ☐ Recover (New roof over existing Roofing System) ☐ Reroof (New cover/remove existing roofing system to deck) ☐ Other		
FM Approved RoofNav Assembly Numbers:		

ROOF SURFACING:

☐ None	
☐ Coating	*(Trade Name/Application Rate)*
☐ Granules	*(Application Rate)*
☐ Gravel/Slag	*(Application Rate)*
☐ Ballast: ☐ Stone Size ☐ Pavers *(Beveled or square edge)*; ☐ Other:	
Ballast Weight (psf): Field: Perimeter: Corners:	

ROOF COVER/MEMBRANE:
(Please provide ALL applicable details including trade name, type, number of plies, thickness, reinforced, adhesive)

☐ Panel: ☐ Through Fastened Metal ☐ Standing Seam metal ☐ Fiber Reinforced Plastic (FRP) ☐ Other:			
☐ Built Up Roofing (BUR)			
☐ Modified Bitumen			
☐ Single Ply:	☐ Adhered	☐ Fastened	☐ Ballasted
☐ Spray Applied			
☐ Other:			

BASE SHEET:
(Please include Trade Name, Type, and Width)

☐ None		
Trade Name:		Width: ☐ 36 In. ☐ 1 meter (39 In.)
☐ Fastened		☐ Adhered
☐ Secured per RoofNav	**OR**	☐ Per FM Global Loss Prevention Data Sheet 1-29
Comments:		
☐ Air Retarder		
☐ Vapor Retarder		

INSULATION

Layer	Trade Name	Thickness (In.)	Fastened	Adhered	Tapered
1. Top			☐	☐	☐
2. Next			☐	☐	☐
3. Next			☐	☐	☐
4. Next			☐	☐	☐

☐ Glass Fiber/Mineral Wool/Batt	☐ Facer Type/Vapor Barrier
☐ Thermal Barrier	

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SAMPLE FM GLOBAL CHECKLIST FOR ROOFING SYSTEMS – page 2

CHECKLIST FOR ROOFING SYSTEM

☐ Other:	
☐ None	

DECK:
(Please include manufacturer, type, yield strength, thickness/gage, etc.)

☐ Steel:	
☐ LWIC (Form Deck):	☐ Cementitious Wood Fiber:
☐ Concrete: ☐ Pre-cast panels or ☐ Cast in Place	
☐ Wood	
☐ Fiber Reinforced Cement	☐ Fiber Reinforced Plastic
☐ Gypsum: ☐ Plank	☐ Poured
☐ Other:	
Comments:	

ROOF STRUCTURE (Include Size, Gage, Etc.):

☐ Purlins ☐ "C" OR ☐ "Z"		
☐ Joists ☐ Wood OR ☐ Steel		
☐ Beams ☐ Wood OR ☐ Steel		
☐ Other:		
Spacing: Field:	Perimeter:	Corners:
Comments:		

FASTENERS USED IN ROOF ASSEMBLY:

Roof Cover Fasteners: Trade Name:		Length:	Diameter:
Stress Plate/Batten:			
Spacing: Field: X	Perimeter: X	Corners: X	
Insulation Fasteners: Trade Name:		Type:	
Size:		Stress Plate:	
Spacing: Field:	Perimeter:	Corners:	
Deck Or Roof Panels Fasteners: Trade Name:		Type:	
Length:		Size Washer:	
If Weld: Size:	Weld:	Washer:	
Deck Side Lap Fasteners: Field: X	Perimeter: X	Corners: X	
Spacing: Field: X	Perimeter: X	Corners: X	
Base Sheet Fasteners Trade Name:		Type:	
Head Diameter:		Length:	
Spacing: (Attached Sketches as necessary) Spacing Along Laps: Field:		Perimeter:	Corners:
No. Intermediate Rows: Field:		Perimeter:	Corners:
Spacing Along Intermediate Rows: Field:		Perimeter:	Corners:

PERIMETER FLASHING:
(Attach a detailed sketch of metal fascia, gravel stop, nailer, coping, etc.)

☐ FM Approved Flashing	☐ Per FM Global Loss Prevention Data Sheet 1-49
☐ Other:	Comments:

DRAINAGE:

For new construction: Has roof drainage been designed by a Qualified Engineer per FM Global Loss Prevention Data Sheet 1-54 and the local building code? ☐ Yes ☐ No (Attach details)
For re-roofing and recovering: will the roof drainage be changed from the original design (for example: drain inserts, drains covered or removed, new expansion joints, blocked or reduced scupper size? ☐ Yes ☐ No If yes, were the changes reviewed by a Qualified Engineer? ☐ Yes ☐ No (Attach details)
Is secondary (emergency) roof drainage provided per FM Global Data Sheet 1-54? ☐ Yes ☐ No (Attach details)

X2688 ENGINEERING (Rev. January 2011)

SAMPLE FM GLOBAL CHECKLIST FOR ROOFING SYSTEMS – page 3

CHECKLIST FOR ROOFING SYSTEM

FM Global OFFICE REVIEW
(Please leave blank for FM Global Office Review)

WIND:

Design Wind Speed: *(mph)*	Ground Terrain: ☐ B ☐ C ☐ D
Uplift Pressure in field: *(psf)*	Uplift Rating Required:
Adequate Uplift Rating Provided:	Adequate? ☐ Yes ☐ No

FIRE:

Internal Assembly Rating:	☐ Class 1	☐ Class 2	☐ Non-Combustible	
External Fire Rating:	☐ Class A	☐ Class B	☐ Class C	☐ None
Concealed Spaces?	☐ Yes	☐ No	Sprinklers below Roof?	☐ Yes ☐ No
Adequate?	☐ Yes	☐ No		

HAIL:

Hail Rating Needed?	☐ SH	☐ MH	☐ None	Hail Rating Provided?	☐ SH ☐ MH ☐ None
Adequate?	☐ Yes	☐ No			

COLLAPSE:

If standing seam, has collapse been reviewed? ☐ Yes ☐ No

COMMENTS:

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End of Section 50 60 00 FM Global Checklist for Roofing Systems

Section 50 70 00
Statement of Special Inspections

Statement of Special Inspections

Project: *Master Plan Phase III Renovations and Additions Norwalk Community College*

Location: *188 Richards Avenue, Norwalk, CT*

Owner: *State of Connecticut, Board of Community Technical Colleges*

Design Professional in Responsible Charge: *Sheng Shi, P.E.*

This *Statement of Special Inspections* is submitted as a condition for permit issuance in accordance with the Special Inspection and Structural Testing requirements of the Building Code. It includes a schedule of Special Inspection services applicable to this project as well as the name of the Special Inspection Coordinator and the identity of other approved agencies to be retained for conducting these inspections and tests. This *Statement of Special Inspections* encompass the following disciplines:

☒ Structural ☐ Mechanical/Electrical/Plumbing

☐ Architectural ☒ Other: *Geotech*

The Special Inspection Coordinator shall keep records of all inspections and shall furnish inspection reports to the Building Official and the Registered Design Professional in Responsible Charge. Discovered discrepancies shall be brought to the immediate attention of the Contractor for correction. If such discrepancies are not corrected, the discrepancies shall be brought to the attention of the Building Official and the Registered Design Professional in Responsible Charge. The Special Inspection program does not relieve the Contractor of his or her responsibilities.

Interim reports shall be submitted to the Building Official and the Registered Design Professional in Responsible Charge.

A *Final Report of Special Inspections* documenting completion of all required Special Inspections, testing and correction of any discrepancies noted in the inspections shall be submitted prior to issuance of a Certificate of Use and Occupancy.

Job site safety and means and methods of construction are solely the responsibility of the Contractor.

Interim Report Frequency: *Monthly* or ☐ per attached schedule.

Prepared by:

Sheng Shi, P.E.
(type or print name)

5/11/2018
Signature Date

Design Professional Seal

Owner's Authorization:

Signature Date

Building Official's Acceptance:

Signature Date

Schedule of Inspection and Testing Agencies

This Statement of Special Inspections / Quality Assurance Plan includes the following building systems:

- ☒ Soils and Foundations
- ☒ Cast-in-Place Concrete
- ☐ Precast Concrete
- ☒ Masonry
- ☒ Structural Steel
- ☒ Cold-Formed Steel Framing
- ☐ Spray Fire Resistant Material
- ☐ Wood Construction
- ☐ Exterior Insulation and Finish System
- ☐ Mechanical & Electrical Systems
- ☐ Architectural Systems
- ☐ Special Cases

Special Inspection Agencies	Firm	Address, Telephone, e-mail
1. Special Inspection Coordinator	*TBD*	
2. Inspector	*TBD*	
3. Inspector		
4. Testing Agency	*TBD*	
5. Testing Agency		
6. Other	*Geotech Engineer TBD*	

Note: The inspectors and testing agencies shall be engaged by the Owner or the Owner's Agent, and not by the Contractor or Subcontractor whose work is to be inspected or tested. Any conflict of interest must be disclosed to the Building Official, prior to commencing work.

Quality Assurance Plan

Quality Assurance for Seismic Resistance

Seismic Design Category	*B*
Quality Assurance Plan Required (Y/N)	*N*

Description of seismic force resisting system and designated seismic systems:

Quality Assurance for Wind Requirements

Basic Wind Speed (3 second gust)	*110 MPH*
Wind Exposure Category	*C*
Quality Assurance Plan Required (Y/N)	*N*

Description of wind force resisting system and designated wind resisting components:

Statement of Responsibility

Each contractor responsible for the construction or fabrication of a system or component designated above must submit a Statement of Responsibility.

Qualifications of Inspectors and Testing Technicians

The qualifications of all personnel performing Special Inspection and testing activities are subject to the approval of the Building Official. The credentials of all Inspectors and testing technicians shall be provided if requested.

Key for Minimum Qualifications of Inspection Agents:

When the Registered Design Professional in Responsible Charge deems it appropriate that the individual performing a stipulated test or inspection have a specific certification or license as indicated below, such designation shall appear below the *Agency Number* on the Schedule.

PE/SE	Structural Engineer – a licensed SE or PE specializing in the design of building structures
PE/GE	Geotechnical Engineer – a licensed PE specializing in soil mechanics and foundations
EIT	Engineer-In-Training – a graduate engineer who has passed the Fundamentals of Engineering examination

American Concrete Institute (ACI) Certification

ACI-CFTT	Concrete Field Testing Technician – Grade 1
ACI-CCI	Concrete Construction Inspector
ACI-LTT	Laboratory Testing Technician – Grade 1&2
ACI-STT	Strength Testing Technician

American Welding Society (AWS) Certification

AWS-CWI	Certified Welding Inspector
AWS/AISC-SSI	Certified Structural Steel Inspector

American Society of Non-Destructive Testing (ASNT) Certification

ASNT	Non-Destructive Testing Technician – Level II or III.

International Code Council (ICC) Certification

ICC-SMSI	Structural Masonry Special Inspector
ICC-SWSI	Structural Steel and Welding Special Inspector
ICC-SFSI	Spray-Applied Fireproofing Special Inspector
ICC-PCSI	Prestressed Concrete Special Inspector
ICC-RCSI	Reinforced Concrete Special Inspector

National Institute for Certification in Engineering Technologies (NICET)

NICET-CT	Concrete Technician – Levels I, II, III & IV
NICET-ST	Soils Technician - Levels I, II, III & IV
NICET-GET	Geotechnical Engineering Technician - Levels I, II, III & IV

Exterior Design Institute (EDI) Certification

EDI-EIFS	EIFS Third Party Inspector

Other

_____ _____

Soils and Foundations

Item	Agency # (Qualif.)	Scope
1. Shallow Foundations	*6 PE/GE*	*Inspect soils below footings for adequate bearing capacity and consistency with geotechnical report.* *Inspect removal of unsuitable material and preparation of subgrade prior to placement of controlled fill*
2. Controlled Structural Fill	*6 PE/GE*	*Perform sieve tests (ASTM D422 & D1140) and modified Proctor tests (ASTM D1557) of each source of fill material.* *Inspect placement, lift thickness and compaction of controlled fill.* *Test density of each lift of fill by nuclear methods (ASTM D2922)* *Verify extent and slope of fill placement.*
3. Deep Foundations	*N/A*	*Inspect and log pile driving operations. Record pile driving resistance and verify compliance with driving criteria.* *Inspect piles for damage from driving and plumbness.* *Verify pile size, length and accessories.* *Inspect installation of drilled pier foundations. Verify pier diameter, bell diameter, lengths, embedment into bedrock and suitability of end bearing strata.*
4. Load Testing	*N/A*	
4. Other: *Engineered Fill* *Pipe Trench*	*6* *6 NICET-ST*	*Review submittals for proposed engineered structural fill material* *Confirm the compaction of the backfill material is compacted to at least the specified percent of maximum density as identified in the specification and as determined by ASTM D1557, Method C*

Cast-in-Place Concrete

Item	Agency # (Qualif.)	Scope
1. Mix Design	*2 ACI-CCI ICC-RCSI*	*Review concrete batch tickets and verify compliance with approved mix design. Verify that water added at the site does not exceed that allowed by the mix design.*
2. Material Certification	*2*	*Review certified steel mill test reports; identification markings of concrete reinforcing bars; and cold-formed metal stud material identification marks.*
3. Reinforcement Installation	*2 ACI-CCI ICC-RCSI*	*Inspect size, spacing, cover, positioning and grade of reinforcing steel. Verify that reinforcing bars are free of form oil or other deleterious materials. Inspect bar laps and mechanical splices. Verify that bars are adequately tied and supported on chairs or bolsters*
4. Post-Tensioning Operations	*N/A ICC-PCSI*	*Inspect placement, stressing, grouting and protection of post-tensioning tendons. Verify that tendons are correctly positioned, supported, tied and wrapped. Record tendon elongations.*
5. Welding of Reinforcing	*2 AWS-CWI*	*Visually inspect all reinforcing steel welds. Verify weldability of reinforcing steel. Inspect preheating of steel when required.*
6. Anchor Rods	*2*	*Inspect size, positioning and embedment of anchor rods. Inspect concrete placement and consolidation around anchors.*
7. Concrete Placement	*2 ACI-CCI ICC-RCSI*	*Inspect placement of concrete. Verify that concrete conveyance and depositing avoids segregation or contamination. Verify that concrete is properly consolidated.*
8. Sampling and Testing of Concrete	*2 ACI-CFTT ACI-STT*	*Test concrete compressive strength (ASTM C31 & C39), slump (ASTM C143), air-content (ASTM C231 or C173) and temperature (ASTM C1064).*
9. Curing and Protection	*2 ACI-CCI ICC-RCSI*	*Inspect curing, cold weather protection and hot weather protection procedures.*
10. Other: *Non-shrink grout for steel column base plates.*	*2*	*test compressive strength (ASTM C109)*

Masonry

Required Inspection Level: ☒ **1** ☐ **2**

Item	Agency # (Qualif.)	Scope
1. Material Certification	*2*	*review certified reports and identification markinghs on masonry units.*
2. Mixing of Mortar and Grout	*2 ICC-SMSI*	*Inspect proportioning, mixing and retempering of mortar and grout.*
3. Installation of Masonry	*2 ICC-SMSI*	*Inspect size, layout, bonding and placement of masonry units.*
4. Mortar Joints	*2 ICC-SMSI*	*Inspect construction of mortar joints including tooling and filling of head joints.*
5. Reinforcement Installation	*2 ICC-SMSI* *AWS-CWI*	*Inspect placement, positioning and lapping of reinforcing steel.* *Inspect welding of reinforcing steel.*
6. Prestressed Masonry	*N/A ICC-SMSI*	*Inspect placement, anchorage and stressing of prestressing bars.*
7. Grouting Operations	*2 ICC-SMSI*	*Inspect placement and consolidation of grout. Inspect masonry clean-outs for high-lift grouting.*
7. Weather Protection	*2 ICC-SMSI*	*Inspect cold weather protection and hot weather protection procedures. Verify that wall cavities are protected against precipitation.*
9. Evaluation of Masonry Strength	*2 ICC-SMSI*	*Test compressive strength of mortar and grout cube samples (ASTM C780).* *Test compressive strength of masonry prisms (ASTM C1314).*
10. Anchors and Ties	*2 ICC-SMSI*	*Inspect size, location, spacing and embedment of dowels, anchors and ties.*
11. Other:		

Structural Steel

Item	Agency # (Qualif.)	Scope
1. Fabricator Certification/ Quality Control Procedures ☐ Fabricator Exempt	*2 AWS/AISC-SSI ICC-SWSI*	*Review shop fabrication and quality control procedures.*
2. Material Certification	*2 AWS/AISC-SSI ICC-SWSI*	*Review certified mill test reports and identification markings on wide-flange shapes, high-strength bolts, nuts and welding electrodes*
3. Open Web Steel Joists	*N/A*	
4. Bolting	*2 AWS/AISC-SSI ICC-SWSI*	*Inspect installation and tightening of high-strength bolts. Verify that splines have separated from tension control bolts. Verify proper tightening sequence. Continuous inspection of bolts in slip-critical connections.*
5. Welding	*2 AWS-CWI* *ASNT*	*Visually inspect all welds. Inspect pre-heat, post-heat and surface preparation between passes. Verify size and length of fillet welds.* *Ultrasonic testing of all full-penetration welds.*
6. Shear Connectors	*2 AWS/AISC-SSI ICC-SWSI*	*Inspect size, number, positioning and welding of shear connectors. Inspect suds for full 360 degree flash. Ring test all shear connectors with a 3 lb hammer. Bend test all questionable studs to 15 degrees.*
7. Structural Details	*2 PE/SE*	*Inspect steel frame for compliance with structural drawings, including bracing, member configuration and connection details.*
8. Metal Deck	*2 AWS-CWI*	*Inspect welding and side-lap fastening of metal roof and floor deck.*
9. Other: *Post-installed anchor bolts*	*2*	*Inspect post-installed expansion and adhesive anchor bolts*

Cold Formed Steel Framing

Item	Agency # (Qualif.)	Scope
1. Member Sizes	*2* *AISC-SSI*	*Inspect cold-formed metal stud member size installation*
2. Material Thickness	*2* *AISC-SSI*	*Inspect cold-formed metal stud material thickness*
3. Material Properties	*2* *AISC-SSI*	*Inspect cold-formed metal stud material grade and strength*
4. Mechanical Connections	*2* *AISC-SSI*	*Inspect cold-formed metal stud self-drilling screw connections*
5. Welding	*2* *AWS/AISC-SSI ICC-SWSI*	*Inspect cold-formed metal stud welded connection if applicable*
6. Framing Details	*2* *AISC-SSI*	*Inspect cold-formed metal stud framing configuration in comformance with design intent.*