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# VOLUME 2

## LAKELAND CENTRAL SCHOOL DISTRICT

SHRUB OAK, NEW YORK

PROJECT NO. 276721-23001

RECONTSRUCTION TO
WALTER PANAS HIGH SCHOOL
LAKELAND HIGH SCHOOL
COPPER BEECH MIDDLE SCHOOL

OCTOBER 13, 2023

The engineer that has signed this document certifies that to the best of their knowledge, information and belief, the asbestos plans and specifications are in accordance with applicable requirements of the New York State Uniform Fire Prevention and Building Code, Construction Standards of the Commissioner of Education, New York State Department of Labor Part 56 of Title 12, and the United States Environmental Protection Agency Hazard Emergency Response ACT Regulations. Robert S. Masone is accredited to the EPA and New York State under AHERA Regulations as an Asbestos Project Designer (Asbestos Handling Certificate Number 92-17140).

To the best of the Architect's knowledge, information and belief, the design of this project conforms to all applicable provisions of the New York State Uniform Fire Prevention and Building Code, the New York State Energy Conservation Construction Code, and the building standards of the New York State Education Department.

BID SET

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PROJECT MANUAL

Volume 2 of 2

**BIDDING REQUIREMENTS AND CONDITIONS OF THE CONTRACT**



**PLEASE NOTE**

All sections of the following **SPECIFICATIONS** are sequentially numbered, beginning with Page 1 and concluding with the last numbered page bearing the marking "END OF SECTION -- -- --".

Sections may include additional attachments as noted in following list of Specification sections.

## SPECIFICATIONS

# SECTION 22 05 00 - COMMON WORK RESULTS FOR PLUMBING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following:

1. Definitions, references, and abbreviations.
2. General regulatory requirements.
3. General requirements regarding site/field conditions including existing conditions and field measurements.
4. Sequencing and scheduling including coordination.
5. Definition of design equipment and procedures for consideration of specified equivalents, proposed equivalents, or substitutions.
6. Plumbing requirements for laboratory equipment.
7. Transition fittings.
8. Grout.
9. Plumbing demolition.
10. Equipment installation requirements common to equipment sections.
11. Painting and finishing.
12. Supports and anchorages.

### 1.3 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.

## 1.4 SYSTEM DESCRIPTION

A. Provide complete systems, properly connected, tested, balanced, adjusted, and ready for operation, including all necessary and required controls, safeties, details and accessories, including (but not limited to):

1. Sanitary drainage and vent systems.
2. Storm drainage and roof drainage systems.
3. Plumbing fixtures.
4. Natural gas piping systems.
5. Miscellaneous items.

## 1.5 COORDINATION PROCEDURES

A. Coordinate construction operations and construction schedule of plumbing work with other contractors in accordance with Section 01 31 00 “Project Management and Coordination” and as modified below.

1. Pre-Installation Conference:

   a. Attend pre-installation conference. Arrange for all subcontractors to be in attendance.

2. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

3. Coordinate Plumbing Work with HVAC systems, lighting fixtures, ceiling mounted devices, ceiling heights, materials, structural work, maintenance clearances, and electric code clearance and building systems.

4. Notify Owner's Project Representative and Architect in case of unresolved interferences prior to installation of Plumbing Work.

5. Adjust exact size, location and offsets of pipes to achieve reasonable appearance objectives in open areas without ceilings without increase in Contract Sum.

## 1.6 SUBMITTALS, GENERAL

A. Comply with requirements of SECTION 01 33 00 “Submittal Procedures” for each individual Section and as modified below.

B. Submit all action submittals required by individual Section concurrently.

1. As-Specified Products: If product to be incorporated into Project is as specified by name and product designation in Part 2 of product specification, and will be installed as specified in Part 3, and only where allowed as such in submittal portion of product specification, then submit “**As-Specified Verification Form**” (attached to SECTION 01 33 00 “Submittal Procedures”) in lieu of “Product Data” identified in the Action Submittal.

2. Do not use "**As Specified Verification Form**" unless specifically indicated in detailed product specification.

3. Equivalent Products or Substitutions: If product to be incorporated into Project is not specified by name and product designation in Part 2 below, comply with all Product Data requirements specified.

## 1.7 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sleeves and sleeve seals. Include rated capacities, and furnished specialties and accessories.

1. Penetration firestopping materials.
2. Penetration firestopping assembly drawings.

## 1.8 INFORMATIONAL SUBMITTALS

A. Coordination Drawings.
B. Contract Closeout Submittals: Comply with requirements of Section 01 77 00 "Closeout Procedures".

## 1.9 QUALITY ASSURANCE.

A. Provide installation, testing and materials in accordance with Federal, State and Local Building, Health, Plumbing and Electrical Codes, Laws, Ordinances, and Regulations that apply to Plumbing Work.

1. Comply with applicable requirements of following documents:

a. New York State Uniform Fire Prevention and Building Code.
b. 2020 Building Code of New York State.
c. 2020 Fire Code of New York State.
d. 2020 Plumbing Code of New York State.
e. 2020 Mechanical Code of New York State.
f. 2020 Fuel Gas Code of New York State.
g. 2020 Energy Conservation Construction Code of New York State.
h. New York State Education Department Manual of Planning Standards.
i. In event of a conflict between the Codes identified above and Contract Documents, comply with more stringent requirement.

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

C. 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.

D. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is submitted to the Architect and 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.

## 1.10 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. Packing and Shipping: Ship materials in manufacturer's containers, fully identified with manufacture's name, trade name, type, class, style, model, grade, size and color.

C. Storage and Protection:

1. Store materials, equipment, fixtures, pipe, fittings, and attachments, under cover, off ground in original containers as applicable, and protect from physical and weather damage while in storage and during construction.

2. Furnish extra materials identified in technical sections, in original manufacturers' containers and packaging, to Owner at location identified during prebid conference. Obtain receipt from Owner upon delivery of extra materials and send copy of receipt to Architect.

3. Replace or repair damaged, rusted, corroded or otherwise unusable materials physically damaged or weather damaged equipment as determined by Architect, at no change in Contract Sum.

## 1.11 PROJECT/SITE CONDITIONs

A. Existing Conditions:

1. Reuse equipment only as indicated on Drawings.

2. All usable material and equipment not being reused is to be offered to the Owner. If accepted by Owner the Contractor shall deliver to a location on District grounds designated by the Owner.

3. All other material and equipment to be removed, shall be removed from the site and legally disposed of by the Contractor.

B. Rodent Proofing:

1. Strainer Plates: All strainer plates on drain inlets shall be designed and installed so that all openings are not greater than a 1/2 inch in least dimension. Refer to Section 22 13 19 "Sanitary Waste Piping Specialties" for additional requirements.

2. Openings for Pipes: In or on structures where openings have been made in walls, floors or ceilings for the passage of pipes, such openings shall be closed and protected by the installation of approved metal collars that are securely fastened to the adjoining structure. Refer to Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing piping” and 22 05 18 “Escutcheons for Plumbing Piping” for additional requirements.

C. Protection of Plumbing Systems:

1. Corrosion: Provide corrosion protection for pipes passing through concrete or cinder walls and floors or buried in corrosive soil conditions.

   a. Provide oversized sleeves or core drilled holes to eliminate rubbing on above grade piping installations. Refer to Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping” for pipe sleeve and core drilling requirements.

   b. Refer to individual Division 22 piping Sections for corrosion protection on buried piping installations in corrosive soil conditions.

2. Stress and Strain: Install plumbing systems in a manner that prevents stresses and strains that exceed the structural strength of the pipe. Install piping systems to accommodate expansion, contraction and structural settlement.

3. Freezing: Do not install water, soil, waste or storm piping outside of a building, in attics or crawlspaces, conceal in outside walls or in any other place subjected to freezing temperatures without providing measures to keep the contents of the piping system from freezing.

D. Field Measurements:

1. Layout of equipment, piping, and similar components in Drawings is diagrammatic. Review Drawings to identify interference with other construction and verify dimensions at Site prior to beginning installation.

   a. Obtain exact location of all items and openings and confirm all existing conditions in field.

   b. Obtain exact location and roughing requirements for all equipment furnished by others but installed by this Contractor before roughing. Owner reserves right to make reasonable changes prior to "roughing-in" without increase in Contract Sum.

2. Report any conflicts to Architect in writing before beginning installation.

3. Provide fittings, horizontal and vertical offsets, elevation changes, etc. required to install Plumbing Work. Do not infer that Drawings show level of detail indicating every offset, elbow, union, fitting, elevation changes, or other aspect required for complete installation.

4. Install Plumbing Work with proper provisions for removal and/or access to valves, traps, cleanouts, etc.

## 1.12 SEQUENCING AND SCHEDULING

A. Perform Plumbing Work in cooperation with Owner, Architect, Construction Manager, and all Contractors on this Project, and other separate Contractors at the Site.

1. Coordinate Plumbing Work with construction schedule requirements in Division 01
2. Coordinate all submittals with the construction schedule and with requirements and schedules contained in Section 01 33 00 “Submittals Procedures.”
3. Immediately report any delays in receipt of materials required for Plumbing Work including circumstances causing delays.

B. Refer to Division 01 for cooperation between Contractors. Prior to start of construction:

1. Obtain from Contract Drawings or Architect, exact location of items and openings in construction. Conform to existing conditions in field.

2. Review applicable Shop Drawings of all Contracts.

3. If conflict occurs between Contract Drawings, advise Architect in writing before beginning installation and comply with Architect's directions.

4. Obtain exact location and roughing requirements for equipment furnished by other Contractor or by Owner but installed by Contractor responsible for Plumbing Work before beginning roughing.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Minimum Material Requirements:

1. Construct potable water systems and equipment according to AWWA standards.

2. Provide electrical equipment and systems meeting UL standards and requirements of NEC.

3. Provide UL label on all equipment and material with listing service.

4. Material Flammability:

a. Flame spread rating of 25 or less.
b. Smoke developed rating of 50 or less.

5. Equipment Verification: Carefully check manufacturer's drawings and specifications as they affect their equipment; follow factory instructions for roughing, installation, connection, filling, lubrication, testing, balancing, adjusting, alignment, wiring, and start-up operation.

## 2.2 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
C. Design Mix: 5000 psi, 28-day compressive strength.
D. Packaging: Premixed and factory packaged.

## 2.3 SEALANTS

A. Comply with requirements for sealants in non-fire rated penetrations specified in Section 07 92 00 "Joint Sealants."

B. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. GE Construction Sealants; Momentive Performance Materials Inc.
2. Sherwin-Williams Company (The).
3. Sika Corporation.
4. The Dow Chemical Company.

D. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.

## 2.4 PENETRATION FIRESTOPPING

A. Comply with requirements for sealants in fire rated penetrations specified in Section 07 84 13 “Penetration Firestopping”.

B. Submit Manufacturers Product Data Sheets for each type of product selected. Certify that Firestop Material is free of asbestos and lead paint and complies with local regulations.

1. Certification by firestopping manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs) and are nontoxic to building occupants.

C. Submit system design listings, including illustrations from qualified testing and inspection agency that is applicable to each firestop configuration.

D. Submit a project specific Penetration Firestopping Schedule indicating where each firestop configuration will be used.

## 2.5 PAINT AND FINISHES

A. Refer to Section 09 91 00 "Painting" for interior painting and finishing of plumbing piping, equipment and systems.

## 2.6 LABORATORY EQUIPMENT AND FIXTURES

A. Refer to Section 12 32 13 "Manufactured Wood-Veneer-Faced Casework" for laboratory equipment and fixtures requiring plumbing piping rough-ins and connections.

B. Provide plumbing piping rough-ins, traps, drains, supplies with stops and escutcheon plates for connections to fixtures and equipment provided in Section 12 32 13 "Manufactured Wood-Veneer-Faced Casework".

C. Provide chrome plating on exposed metallic water and gas piping, valves, etc.

D. Install sink drains and tailpieces furnished by Section 12 32 13 "Manufactured Wood-Veneer-Faced Casework". Obtain receipt of delivery for materials supplied by other Prime Contractors.

E. Install emergency eye wash equipment fittings and fixtures, i.e. eye wash, sink drains, tailpieces, etc. Obtain receipt of delivery for materials supplied by other Prime Contractors.

F. Install emergency eyewash and shower equipment fittings and fixtures, i.e. sink drains, eyewash shower head, tailpieces, etc. Obtain receipt of delivery for materials supplied by other Prime Contractors.

G. Coordinate size, location and number of hole punches required for installation of plumbing faucets and counter mounted turrets with Laboratory Equipment Installer in ample time for holes to be indicated on Roughing Drawings and Assembly Drawing from Laboratory Equipment Installer and Casework Installer.

H. Verify exact locations and roughing-in dimensions for each connection and installation from Roughing Drawings and Assembly Drawings of laboratory casework and equipment accepted by Architect before beginning installation. Obtain Roughing Drawings and Assembly Drawings from Laboratory Equipment Installer and Casework Installer.

I. Adjust rough in as required for complete and operable installation meeting installation guidelines established by equipment manufacturer.

## 2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

1. Dielectric Unions:

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) Capitol Manufacturing Company.
2) Central Plastics Company.
3) Hart Industries International, Inc.
4) Jomar International Ltd.

5) Matco-Norca, Inc.
6) McDonald, A. Y. Mfg. Co.
7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
8) Wilkins; a Zurn company.

b. Description:

1) Standard: ASSE 1079.
2) Pressure Rating: 125 psig minimum at 180 deg F.
3) End Connections: Solder-joint copper alloy and threaded ferrous.

## PART 3 - EXECUTION

### 3.1 PLUMBING DEMOLITION

A. Refer to Section 02 41 19 "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Remove Piping: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Abandon Piping in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Remove Equipment: Disconnect and cap services and remove equipment.
4. Remove and Reinstall Equipment: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Remove and Salvage Equipment: 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 rendered unserviceable during the process of demolition, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

### 3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Unless specific mounting heights are indicated, install equipment to allow maximum possible headroom.

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.

## 3.3 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.

## 3.4 SEALANTS

A. Install sealants according to the requirements specified in Section 07 92 00 "Joint Sealants."
B. Refer to individual Division 22 plumbing fixture and equipment Sections for specific sealant and caulking requirements.

## 3.5 FIRESTOPPING

A. Install firestopping according to the requirements specified in Section 07 84 13 "Penetration Firestopping."

B. Applied Fireproofing:

1. Coordinate the installation of hangers, supports and accessories from the structural steel with the fireproofing installation. Install all hangers and supports prior to installation of fireproofing.

2. Repair or replace existing fireproofing removed as a part of Plumbing Work installation.

   a. Employ the services of an approved fireproofing contractor to repair or replace the fireproofing by patching any areas that have been removed or damaged due to the installation of work after the completion of the fireproofing.

   b. Repaired or replacement fireproofing shall match the fireproofing adjacent to the repaired area. All warranties shall be maintained.

## 3.6 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Section 09 91 00 "Painting."
B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

## 3.7 DIELECTRIC FITTINGS

A. Install dielectric fittings according to the specific requirements in the Division 22 Sections specifying piping systems.

## 3.8 TRANSITION FITTINGS

A. Install transition fittings according to the specific requirements in the Division 22 Sections specifying piping systems.

END OF SECTION 22 05 00

# SECTION 22 05 17 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Sleeve-seal systems.
2. Grout.
3. Silicone sealants.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sleeves seals.

1. Sleeve-seal systems.
2. Firestopping.

### 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

## PART 2 - PRODUCTS

### 2.1 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
C. Steel Sheet Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint

### 2.2 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, LLC.
2. CALPICO, Inc.
3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Designed to form a hydrostatic seal of 20 psig minimum.

2. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Sealing Elements (Natural Gas and Propane Gas Systems): NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

4. Pressure Plates: Stainless steel, Type 316.

5. Connecting Bolts and Nuts: Stainless steel, Type 316 of length required to secure pressure plates to sealing elements.

## 2.3 PENETRATION FIRESTOPPING

A. Comply with requirements for sealants in fire rated penetrations specified in Section 07 84 13 “Penetration Firestopping” and Section 22 05 00 “Common Work Results for Plumbing.”

## 2.4 GROUT

A. Refer to grout product requirements specified in Section 22 05 00 “Common Work Results for Plumbing.”

## 2.5 SILICONE SEALANTS

A. Comply with requirements for silicone sealants specified in Section 07 92 00 "Joint Sealants" and Section 22 05 00 “Common Work Results for Plumbing.”

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION OF SLEEVES - GENERAL

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-inchannular clear space between piping and concrete slabs and walls.

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

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 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. Run pipe insulation continuously through sleeve.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
4. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

## 3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. 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 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
2. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

## 3.5 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above and below Grade:

    a. Sleeves with waterstops.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

2. Concrete Slabs-on-Grade:

    a. Sleeves with waterstops.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

    a. Sleeves with waterstops.

4. Interior Partitions:

    a. Sleeves without waterstops.

END OF SECTION 22 05 17

# SECTION 22 05 18 - ESCUTCHEONS FOR PLUMBING PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes escutcheons and floor plates.

## PART 2 - PRODUCTS

### 2.1 ESCUTCHEONS

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

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. ProFlo; a Ferguson Enterprises, Inc. brand.

B. Escutcheon Types:

1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.
3. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
4. Split-Plate, Stamped-Steel Type: With polished, 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 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 INSTALLATION

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

### 3.3 ESCUTCHEONS APPLICATION

A. Escutcheons for New Piping and Relocated Existing Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.

2. Chrome-Plated Piping: One piece, cast brass with polished, chrome-plated finish.

3. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

4. Bare Piping at Wall, Floor or Ceiling Penetrations in Finished Spaces: One piece, cast brass or split-casting brass type with polished, chrome-plated finish.

5. Bare Piping in Unfinished Service Spaces or Equipment Rooms: One piece, stamped steel or split plate, stamped steel with concealed hinge with polished, chrome-plated finish.

B. Escutcheons for Existing Piping (only required where impacted by new walls, floors or ceilings):

1. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
2. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
3. Bare Piping at Wall, Floor or Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
4. Bare or Insulated Piping in Unfinished Service Spaces and Equipment Rooms: No escutcheons required.

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.

## 3.4 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 22 05 18

# SECTION 22 05 19 - METERS AND GAUGES FOR PLUMBING PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Thermometers.

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals required by this Section concurrently.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sleeves and sleeve seals. Include rated capacities, and furnished specialties and accessories.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. Liquid-in-glass thermometers.
2. Thermowells.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of gauge to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Domestic water for plumbing piping intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.

2.2 THERMOMETERS, LIQUID IN GLASS, LEAD FREE - PLASTIC CASE, INDUSTRIAL STYLE:

A. Basis-of-Design Product: Subject to compliance with requirements, provide Weiss Instruments, Inc; Vari-angle Model 9VU Series or a comparable product by one of the following:

1. Ernst Flow Industries.
2. WATTS; A Watts Water Technologies Company.

B. Source Limitations: Provide liquid-in-glass, lead-free, plastic-case, industrial-style thermometers from single manufacturer.

C. Standard: ASME B40.200.

D. Case: GE Valox® polyester, 40 percent glass/mineral reinforced; 9-inch nominal size unless otherwise indicated.

E. Case Form: Adjustable angle unless otherwise indicated.

F. Tube: Glass with magnifying lens and blue organic liquid, mercury free.

G. Tube Background: Nonreflective aluminum with permanent scale markings graduated in deg F.

H. Window: Glass.

I. Stem: Aluminum, lead-free brass, or stainless steel and of length to suit installation.

1. Design for Thermowell Installation: Bare stem.

J. Connector: 1-1/4 inches, with ASME B1.1 or ASME B1.20.1 screw threads to fit thermowell.

K. Accuracy: Plus or minus 1 percent of span or one scale division, to a maximum of 1.5 percent of span.

## 2.3 THERMOWELLS, LEAD FREE

A. Standard: ASME B40.200.
B. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
C. Material for Use with Copper Tubing: Lead-free copper.
D. Material for Use with Steel Piping: Type 304 stainless steel.
E. Type: Stepped shank unless straight or tapered shank is indicated.
F. External Threads: NPS 1/2, NPS 3/4, or NPS 1, or as required to match threaded opening in pipe.
G. Internal Threads: Size and thread type as required to match thermometer mounting threads.
H. Bore: Diameter required to match thermometer bulb or stem.
I. Insertion Length: Length to extend to match thermometer stem length.
J. Lagging Extension: Include on thermowells for insulated piping and tubing. Extension is to be of sufficient length to extend beyond finished insulation surface.
K. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
L. Heat-Transfer Medium: Mixture of graphite and glycerin.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION OF METERS AND GAUGES

A. Install thermometer with thermowell at each required thermometer location.
B. Install thermowells in vertical position in piping tees.
C. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
D. Install thermowells with extension on insulated piping.
E. Fill thermowells with heat-transfer medium.
F. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

## 3.3 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

## 3.4 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.
B. Adjust faces of meters and gauges to proper angle for best visibility.

## 3.5 THERMOMETER, LEAD FREE, APPLICATION

A. Thermometers at the outlet of each thermostatic mixing valve are to be the following:

1. Plastic case, industrial-style, liquid-in-glass type.

B. Thermometer stems are to be of length to match thermowell insertion length.

## 3.6 THERMOMETER, LEAD FREE, SCALE-RANGE APPLICATION

A. Scale Range for Domestic Water Piping: 30 to 240 deg F.
B. Insert additional paragraphs for thermometer scale ranges and applications.

END OF SECTION 22 05 19

# SECTION 22 05 23 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Ball valves.
2. Check valves.

### 1.3 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene copolymer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.
F. RPTFE: Reinforced polytetrafluoroethylene.
G. RS: Rising stem.
H. SWP: Steam working pressure.
I. WOG: Water, oil, gas.

### 1.4 SUBMITTALS, GENERAL

A. General: Submit all action submittals required by this Section concurrently.

### 1.5 ACTION SUBMITTALS

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

1. Ball valves.
2. Check valves.

### 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 B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder-joint connections.
5. ASME B31.9 for building services piping valves.

C. NSF Compliance:

1. NSF/ANSI-61- Drinking Water System Components - Health Effects.
2. NSF/ANSI-61-8 Commercial Hot 180°F (includes Annex F and G).
3. NSF/ANSI-372 for lead-free valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

## 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 ball valves open to minimize exposure of functional surfaces.
4. 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 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for cast copper solder-joint connections.
5. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
6. ASME B16.34 for flanged and threaded end connections.
7. ASME B16.51 for press joint.
8. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Type:

1. Hand Lever: For quarter-turn valves NPS 4 and smaller except plug valves.
2. Handwheel: For valves other than quarter-turn types.
3. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug-valve head.

H. Valves in Insulated Piping:

1. Ball Valves: Provide 2-inch extended neck stems.
2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

I. Refer to valve schedule articles for applications of valves.

J. Valve Bypass and Drain Connections: MSS SP-45.

## 2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, Lead-Free, Two-Piece with Full Port, and Stainless-Steel Trim, Solder or Threaded Ends (NPS 2 and smaller):

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model S/T-585-66-LF-NS or a comparable product by one of the following:

    a. Conbraco Industries, Inc.; Apollo Valves; 70LF-140, 70LF-240.
    b. Hammond Valve.
    c. Milwaukee Valve Company.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc; LFB6000-SS, LFB6001-SS.

2. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig.
    c. CWP Rating: 600 psig.
    d. Body Design: Two piece.
    e. Body Material: Bronze.
    f. Ends: Soldered or threaded.
    g. Seats: PTFE or TFE.
    h. Stem: Type 316 stainless steel.
    i. Ball: Type 316 stainless steel, vented.
    j. Port: Full.
    k. Handle: Insulated extension handle.

B. Bronze Ball Valves, Lead-Free, Two-Piece with Full Port, and Stainless-Steel Trim, Press Ends (NPS 2 and smaller):

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model PC-585-80-LF-NS or a comparable product by one of the following:

    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. Hammond Valve.
    c. Milwaukee Valve Company.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-110 or MSS-145.
    b. CWP Rating: Minimum 200 psig.
    c. Body Design: Two piece.
    d. Body Material: Bronze.
    e. Ends: Press.
    f. Press Ends Connections Rating: Minimum 200 psig.
    g. Seats: Reinforced PTFE.
    h. Stem: Bronze or brass.
    i. Ball: Stainless steel.
    j. Port: Full.

k. O-Ring Seal: EPDM.
l. Handle: Insulated extension handle.

## 2.4 SILICON BRONZE LIFT CHECK VALVES

A. Bronze Lift Check Valves with Nonmetallic Disc, Class 125:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model T/S-480-Y-LF or a comparable product by one of the following:

a. Hammond Valve.
b. Milwaukee Valve Company.
c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-139.
b. CWP Rating: 250 psig.
c. Body Design: Vertical or horizontal flow.
d. Body Material: Silicon bronze (ASTM Listed), corrosion resistant.
e. Ends: Threaded or soldered.
f. Disc: PTFE.

# 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.

F. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION OF VALVES

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 check valves for proper direction of flow and as follows:

1. Lift Check Valves: With stem upright and plumb.

F. Valve Tags: Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

## 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 valves.

2. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze lift check valves with nonmetallic disc.

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 or press-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

## 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 Ball Valves: Two-piece with full port and bronze or brass trim. Provide with threaded, solder or press connection-joint ends.
3. Bronze Swing Check Valves: Class 125, nonmetallic disc.

## 3.6 SANITARY-WASTE VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two-piece, full port, bronze with stainless-steel trim.
3. Bronze Lift Check Valves: Class 125, nonmetallic disc.

END OF SECTION 22 05 23

# SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Equipment supports.

### 1.3 DEFINITIONS

A. Hostile Environments: Pool mechanical rooms, natatorium spaces, rooms or spaces where corrosive chemicals are stored.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sleeves and sleeve seals. Include rated capacities, and furnished specialties and accessories.

1. Insulation shields.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. Threaded rod.
2. Adjustable clevis hanger.
3. Adjustable swing-ring band hangers.
4. Adjustable swivel-ring band hangers.
5. Hinged pipe clamps.
6. Pipe stands
7. Adjustable pipe saddle supports.

8. Riser clamps.
9. Beam Clamps.

## 1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

## 1.6 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

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. Anvil International; a subsidiary of Mueller Water Products Inc.
2. Cooper B-Line, Inc.
3. ERICO International Corporation.
4. PHD Manufacturing, Inc.

## 2.2 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, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
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 and Tube 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.

## 2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, 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.

## 2.4 THERMAL HANGER-SHIELD INSERTS

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

1. Buckaroos, Inc.
2. CADDY; brand of nVent Electrical plc.
3. Carpenter & Paterson, Inc.
4. Pipe Shields Inc.

B. Insulation-Insert Material for Type "B" and “E” Insulated Piping Support Assemblies: ASTM C552, Type II cellular glass with 100-psig or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Type "C" and “F” Insulated Piping Support Assemblies: Water-repellent-treated, ASTM C533, 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 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.

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

a. Hilti, Inc.
b. ITW Ramset/Red Head; Illinois Tool Works, Inc.

c. MKT Fastening, LLC.
d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

a. Cooper B-line; brand of Eaton, Electrical Sector.
b. Empire Tool and Manufacturing Co., Inc.
c. Hilti, Inc.
d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
e. MKT Fastening, LLC.

2. Indoor Applications: Zinc-coated or stainless steel.

3. Outdoor Applications: Stainless steel.

## 2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

## 2.7 MATERIALS

A. Carbon Steel: ASTM A1011/A1011M.

B. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

C. Stainless Steel: ASTM A240/A240M.

D. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink 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 APPLICATION

A. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. 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.

## 3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. 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/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 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.

E. Pipe Stand Installation:

1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. 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.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. 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.

K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. 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.

M. 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.

5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

## 3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.

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/D1.1M 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, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those 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 Section 09 91 00 "Painting" for interior instllations and Section 09 96 00 "High-Performance Coatings" for exterior installations.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

## 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-58 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 finishes.

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 attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel 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. Piping in general service applications:

a. Bare Copper Piping Systems:

1) NPS 1-1/4 and Smaller: Adjustable, plastic coated copper swivel loop hanger for suspension of non-insulated stationary pipes.
2) NPS 1-1/2 and Larger: Copper plated clevis hanger for suspension of non-insulated stationary pipes. Hanger sized on outside pipe diameter.

b. Bare Ferrous Piping Systems:

1) NPS 1-1/4 and Smaller: Heavy duty electro-galvanized steel swivel loop hanger for suspension of non-insulated stationary pipes.
2) NPS 1-1/2 and Larger: Electro-galvanized clevis hanger for suspension of non-insulated stationary pipes. Hanger sized on outside pipe diameter.

c. Insulated Piping Systems:

1) NPS 2 and Smaller: Electro-galvanized clevis hanger with galvanized steel thermal-hanger shield insert for suspension of insulated stationary pipes. Hanger sized on outside insulation diameter.

2) NPS 2-1/2 and Larger: Electro-galvanized clevis hanger with separate or integral galvanized steel thermal-hanger shield insert for suspension of insulated stationary pipes. Hanger sized on outside insulation diameter.

2. Piping in hostile environment applications:

a. Bare Copper and Ferrous Piping Systems: Stainless steel clevis hanger for suspension of non-insulated stationary pipes. Hanger sized on outside pipe diameter.

b. Bare Plastic Piping Systems: Stainless steel clevis hanger with 18 inch stainless steel thermal-hanger shield insert for suspension of non-insulated stationary pipes. Hanger sized on outside pipe diameter.

c. Insulated Piping Systems: Stainless steel clevis hanger with stainless steel thermal-hanger shield insert for suspension of insulated stationary pipes. Hanger sized on outside insulation diameter.

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 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg 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. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one 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.

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 22 05 29

# SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Equipment and piping labels.
2. Valve tags and signage.

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Warning signs/labels.
2. Valve function signage.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. Equipment labels.
2. Pipe labels.
3. Valve tags.

C. Samples: For color, letter style, and graphic representation required for each identification material and device.

D. Valve-numbering scheme.

E. Valve Schedules: For each piping system. Include in operation and maintenance manuals.

## 1.5 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. Brady, Inc.
2. Craftmark Pipe Markers.
3. Seton, Inc.

B. Plastic Labels:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.

2. Letter and Background Color: As indicated for specific application under Part 3.

3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.

6. Fasteners: Stainless steel rivets or self-tapping screws.

7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

## 2.2 PIPE 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. Brady, Inc.
2. Craftmark Pipe Markers.
3. Seton, Inc.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing and separate self-adhesive direction arrow tape on each end fully wrapped around pipe.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

## 2.3 VALVE TAGS

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

1. Brady Corporation.
2. Craftmark Pipe Markers.
3. Kolbi Pipe Marker Co.
4. Marking Services Inc.
5. Pipemarker.com; Brimar Industries, Inc.
6. Seton Identification Products; a Brady Corporation company.

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass link chain or S-hook.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. 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. Include valve-tag schedule in operation and maintenance data.

## 2.4 VALVE FUNCTION SIGNAGE

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. Brady, Inc.
2. Craftmark Pipe Markers.
3. Seton, Inc.

B. Plastic Signage:

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: White.

3. Background Color: Black.

4. Maximum Temperature: Able to withstand temperatures up to 160 deg 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. Signage Content: Include valve's unique verbiage where indicated on Drawings, unless otherwise specified.

1. Branch shut-off valves serving emergency fixtures: Text to read “Emergency Fixture-No Unauthorized Shut-Off”.
2. Natural Gas Service valve serving an emergency power source: Text to read “SHUT-OFF TO AN EPS”.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

### 3.2 INSTALLATION, GENERAL REQUIREMENTS

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.
D. Locate identifying devices so that they are readily visible from the point of normal approach.

## 3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of plumbing equipment.

B. Sign and Label Colors.

1. White letters on an ANSI Z535.1 safety-green background.

C. Locate equipment labels where accessible and visible.

D. Provide nameplates for equipment with identifying name of equipment and function.

E. Provide name plates for panels identifying name of panel and function, function of switches, control devices, panel lights, and buttons and securely fasten to panels.

F. Locate warning signs for high efficiency water heater vents run horizontally through an exterior wall at a minimum of 8 feet above finished grade.

## 3.4 INSTALLATION OF PIPE LABELS

A. Piping Color Coding: Painting of piping is specified in Section 09 91 00 "Painting."

B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

C. Pipe-Label Locations: 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. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.

D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

E. Flow-Direction Flow Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

F. Pipe-Label Color Schedule:

1. Domestic Cold-Water Piping: Black letters on an ANSI Z535.1 safety-green background.
2. Domestic Hot-Water Piping: Black letters on an ANSI Z535.1 safety-green background.
3. Domestic Hot-Water Return Piping Black letters on an ANSI Z535.1 safety-green background.

4. Sanitary Waste and Storm Drainage Piping: Black letters on an ANSI Z535.1 safety-green background.

G. Trap Primer Water Piping: Provide Piping Identification Labels on exposed water piping between trap primers and drain connections exceeding 10 feet in length at 5-foot intervals. Text to read "Non-potable Water".

## 3.5 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, 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 in the operating and maintenance manual.

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 Color: Natural.
2. Letter Color: Black.

C. Provide valve tag for each piping systems valve located above grade.

1. Valve Directory: Provide neat typewritten directory listing valve function, location and identification number.
2. Valve Numbering System: Extension of and compatible with existing valve numbering system, where valves are installed in existing building or in addition to existing building.
3. Verification: Verify existing valve numbers in field and provide valve numbering avoiding duplication of existing numbers.

END OF SECTION 22 05 53

# SECTION 22 07 19 - PLUMBING PIPING INSULATION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Plumbing vents within 10 feet of a roof penetration.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

1. Flexible elastomeric insulation.
2. Mineral-fiber, preformed pipe insulation.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

### 1.5 QUALITY ASSURANCE

A. Installer Qualifications: Provide insulation system installation by qualified Installers who are trained in installation of each proposed insulation material and product with at least one of the following qualifications:

1. Have successfully completed a Mechanical Insulation Apprenticeship program by the Department of Labor, Bureau of Apprenticeship and Training,
2. Have successfully completed an ASHRAE / NIA 8-hour Mechanical Insulation Training course or equal, or
3. Have five years documented experience as a mechanical insulation specialist with references attesting to successful completion of at least three comparable projects.

## 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 sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

## 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 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

## 2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General" and "Indoor Piping Insulation 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 C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular 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. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

G. 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-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Glass-Fiber Loose-Fill Insulation: Comply with requirements for glass-fiber loose-fill insulation specified in Section 07 21 00 "Thermal Insulation."

I. Spray polyurethane foam: Comply with requirements for spray polyurethane foam specified in Section 07 21 00 "Thermal Insulation."

## 2.3 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. Flexible Elastomeric and Polyolefin 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 LLC; Armaflex 520 Adhesive.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. 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 Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.4 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.

3. Thickness: 11.5 mils.

4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. 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. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.

3. Thickness: 6 mils.

4. Adhesion: 64 ounces force/inch in width.

5. Elongation: 500 percent.

6. Tensile Strength: 18 lbf/inch in width.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 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 piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of 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. 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.

3. 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. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere and seal patches similar to butt joints.

O. 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. Cleanouts.

5. Loose-Fill Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft.

6. Spray Polyurethane Foam: Apply according to manufacturer's written instructions.

   a. Trim and dress surface of spray polyurethane foam to provide smooth, flush surface.

## 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 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 Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

   1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies.
   3. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

## 3.5 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 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 times the thickness of pipe insulation, or one 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 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. 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. 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.

## 3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
2. 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 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.

C. 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.

## 3.7 PIPING INSULATION SCHEDULE, GENERAL

A. 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.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

## 3.8 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water (General Building Areas):

1. Mineral-Fiber, Preformed Pipe Insulation with factory applied jacket, Type I:1-inch thickness.

B. Domestic Cold Water located within Masonry Block Wall cores or buried conduits:

1. Flexible Elastomeric Insulation: 1/2-inch thick.

C. Domestic Hot and Recirculation Water (General Building Areas):

1. Mineral-Fiber, Preformed Pipe Insulation with factory applied jacket, Type I:

a. Pipe sizes 1 1/4" or smaller: 1-inch thickness.
b. Pipe sizes 1 1/2" or larger: 1-1/2-inch thickness.

D. Domestic Hot and Recirculation Water located within Masonry Block Wall cores or buried conduits:

1. Flexible Elastomeric Insulation:

a. Pipes sizes 1 1/4" or smaller: 1/2-inch thickness.

E. Sanitary vent pipes within 10-feet of a roof penetration:

1. Mineral-Fiber, Preformed Pipe Insulation with factory applied jacket, Type I:1-inch thickness.

END OF SECTION 22 07 19

# SECTION 22 11 16 - DOMESTIC WATER PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Piping joining materials.
2. Transition fittings.
3. Dielectric fittings.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Pipe and tube.
2. Fittings.
3. Joining materials.

### 1.4 INFORMATIONAL SUBMITTALS

A. Lab results for lead testing prior to commencing work.
B. System purging and disinfecting activities report.
C. Field quality-control reports.
D. Lab results for biological testing showing samples negative for coliform bacteria.

### 1.5 QUALITY ASSURANCE

A. Installer Qualifications: Installers of pressure-sealed joints are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

### 1.6 FIELD CONDITIONS

A. Interruption of Existing Water Service: Refer to “Existing Utility Interruptions” paragraph of Section 01 12 00 “Multiple Contract Summary-Project Schedule” for requirements associated with interrupting the existing water service to facilities occupied by the Owner.

B. Coordinate potable water lead testing with Owner prior to starting any construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Domestic water piping, tubing, fittings, joints, and appurtenances intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PIPING MATERIALS

A. Potable-water piping and components are to comply with NSF 14, NSF 61, and NSF 372.

2.3 COPPER TUBE AND FITTINGS - DOMESTIC WATER

A. Drawn-Temper Copper Tube: ASTM B88, Type L.

B. Annealed-Temper Copper Tube: ASTM B88, Type L.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than NPS 4.

F. Cast 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. Do not use solder joints on pipe sizes greater than NPS 4.

G. Wrought Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.

H. Pressure-Seal-Joint Fittings, Copper or Bronze - Domestic Water:

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

a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Elkhart Brass Mfg. Co., Inc.
c. FNW; Ferguson Enterprises, Inc.
d. Mueller Streamline Co.; a company of Mueller Industries.
e. NIBCO INC.
f. Viega LLC.

2. Source Limitations: Obtain pressure-seal-joint fittings, copper or bronze, from single manufacturer.

3. Housing: Copper.

4. O-Rings and Pipe Stops: EPDM.

5. Tools: Manufacturer's special tools.

6. Minimum 200 psig working-pressure rating at 250 deg F.

## 2.4 PIPING JOINING MATERIALS - DOMESTIC WATER

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. 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.

D. Flux: ASTM B813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

## 2.5 TRANSITION FITTINGS - DOMESTIC WATER

A. Install transition couplings at joints of piping with small differences in OD's. Refer to transition fitting products specified in Section 22 05 00 “Common Work Results for Plumbing”.

## 2.6 DIELECTRIC FITTINGS - DOMESTIC WATER

A. Dielectric Unions and Flanges: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Comply with requirements in Section 22 05 00 "Common Work Results for Plumbing."

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Before proceeding with water piping installation, examine conditions existing at Site and notify affected Contractors and Architect of any construction or any other conditions prevailing which prevent, inhibit, or otherwise interfere with water piping installation.

B. Potable water testing for lead prior to commencing any work: A baseline for lead testing must be set. Coordinate with Owner on any potable water system lead testing previously performed in each building where modifications to the potable water systems are to take place.

1. If lead testing results were performed in the last year and are available, they may be used as a baseline for lead testing.
2. If lead testing results are not available, test for lead in accordance with Article [**3.13**] - FIELD QUALITY CONTROL below.

C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

## 3.2 PIPING APPLICATIONS

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. Aboveground domestic water piping, NPS 4or smaller is to be one of the following:

1. Drawn-temper copper tube, ASTM B88, Type L; cast-copper, solder-joint fittings; and soldered joints.
2. Drawn-temper copper tube, ASTM B88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

## 3.3 INSTALLATION OF PIPING

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 in accordance with CDA's "Copper Tube Handbook."

C. Install underground copper tube in PE encasement in accordance with ASTM A674 or AWWA C105/A21.5.

D. Install valves in accordance with Section 22 05 23 "General Duty Valves for Plumbing Piping."

E. Install domestic water piping level without pitch and plumb.

F. Rough-in domestic water piping for water-meter installation in accordance with utility company's requirements.

G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

H. 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.

I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

J. Install piping to permit valve servicing.

K. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

L. Install piping free of sags and bends.

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

N. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

## 3.4 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 in accordance with 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. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings in accordance with ASTM B828 or CDA's "Copper Tube Handbook."

E. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools and procedure recommended by pressure-seal-fitting manufacturer. Leave insertion marks on pipe after assembly.

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

## 3.5 INSTALLATION OF TRANSITION FITTINGS

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings.

## 3.6 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings or nipples.

## 3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

B. Install hangers for copper tube and pipe, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting.

D. Support vertical runs of copper tube and pipe to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

## 3.8 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for 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. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.

2. 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.

## 3.9 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

## 3.10 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 in accordance with 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. Repeat procedures if biological examination shows contamination.

e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

## 3.11 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. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
5. Check plumbing specialties and verify proper settings, adjustments, and operation.

## 3.12 FIELD QUALITY CONTROL

A. Potable water testing for lead:

1. Coordinate with Owner on any potable water system lead testing previously performed in each building where modifications to the potable water systems are to take place.

B. Perform the following tests and inspections:

1. Lead Testing Prior to Commencing Construction:

a. Collect and test water samples in accordance with NYS Law 10 CRR-NY 67-4.

b. Collect a first-draw sample from a cold-water outlet at each tap in the building where work is to be performed.

c. Have samples analyzed for lead content by a State Certified testing lab approved to perform such analyses by the Department's Laboratory Approval Program (ELAP). Submit copy of results to Architect/Engineer as a base line of water quality in the building before construction.

1) Notify Owner and Architect in writing of any outlets that exceed the lead action level (5 micrograms per liter).

2. Lead Testing After Construction is Complete:

a. Collect and test water samples in accordance with NYS Law 10 CRR-NY 67-4.

b. Collect a first-draw sample from a cold-water outlet at each tap in the building where work was performed.

c. Have samples analyzed for lead content by a State Certified testing lab approved to perform such analyses by the Department's Laboratory Approval Program (ELAP). Submit copy of results to Architect/Engineer.

d. Replace faucets and/or supply stops with new materials, and retest portion thereof until sample results are below the lead action level (5 micrograms per liter).

3. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been tested and inspected by the Construction Manager.

b. During installation, notify Construction Manager at least two days before inspection must be made. Perform tests specified below in presence of Construction Manager:

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 authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If Construction Manager finds that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

d. Reports: Prepare inspection reports and have them signed by the Construction Manager.

4. Above Grade Piping Tests:

a. Initial Test:

1) Do not connect fixtures, equipment and solenoid valves into system during this test.

2) Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

3) 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.

4) 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.

5) Cap and subject piping to static water pressure of 150 psig, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

6) Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

7) Prepare reports for tests and for corrective action required.

b. Test After Fixtures are Connected:

1) Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

2) Test system again for 2 hours at 75 psig or prevailing water pressure, whichever is higher.

3) Repair leaks and defects at fixture and equipment connections or at solenoid valves, and retest piping or portion thereof until satisfactory results are obtained.

4) Prepare reports for tests and for corrective action required.

C. Domestic water piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 22 11 16

# SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Outlet boxes.
2. Water-hammer arresters.
3. Trap-seal primer device.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for domestic water piping specialties. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. Clothes washer outlet boxes.
2. Icemaker outlet boxes.
3. Supply- seal primer device.

### 1.4 INFORMATIONAL SUBMITTALS

A. Test and inspection reports.
B. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

### 2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

### 2.3 OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Guy Gray, IPS Corporation; Model T200QT or comparable product by one of the following:

    a. Acorn Engineering Company; a Division of Morris Group International.
    b. LSP Products Group.
    c. Oatey.
    d. Sioux Chief Manufacturing Company, Inc.
    e. Water-Tite, IPS Corporation.

2. Mounting: Recessed.

3. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.

4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.

5. Supply Shutoff Fittings: NPS 1/2 ball valves and NPS 1/2 copper, water tubing.

6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.

7. Inlet Hoses: Two 60-inch-long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.

8. Drain Hose: One 48-inch-long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Guy Gray, IPS Corporation; Model MIB1AB or comparable product by one of the following:

   a. LSP Products Group.
   b. Oatey.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Water-Tite, IPS Corporation.

2. Mounting: Recessed.

3. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.

4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.

5. Supply Shutoff Fitting: NPS 1/2 ball valve and NPS 1/2 copper, water tubing.

## 2.4 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters (WHA "A" through "F"):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; 5200 series "Hydrotrol Junior" or comparable product by one of the following:

   a. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Precision Plumbing Products.
   e. Sioux Chief Manufacturing Company, Inc.
   f. WATTS.
   g. Zurn Industries, LLC.

2. Standard: ASSE 1010 or PDI-WH 201.

3. Type: Copper tube with multiple "O" ring pistons.

4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

## 2.5 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Precision Plumbing Products, Inc., Model P1-500 Prime Rite or comparable product by one of the following:

   a. Jay R. Smith Mfg Co; a division of Morris Group International.

b. MIFAB, Inc.
c. Sioux Chief Manufacturing Company, Inc.
d. WATTS.

2. Standard: ASSE 1018.

3. Pressure Rating: 125 psig minimum.

4. Body: Bronze.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.

6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF PIPING SPECIALTIES

A. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. Install 1-1/2-by-3-1/2-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 10 00 "Rough Carpentry."

B. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

C. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

### 3.2 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

### 3.3 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Outlet boxes.
2. Supply-type, trap-seal primer valves.

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 “Identification for Plumbing Piping and Equipment”.

## 3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following 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.

C. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 22 11 19

# SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.

### 1.3 ACTION SUBMITTALS

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

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Heavy-duty, high torque hubless-piping couplings.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. CISPI, low torque hubless-piping couplings.
2. Galvanized-steel pipe and fittings.
3. Copper pipe and fittings.
4. Transition couplings.

### 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.
B. Field quality-control reports.

### 1.5 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Components and installation are capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10 ft. head of water.
2. Waste, Force-Main Piping: 100 psig.

### 2.2 PIPING MATERIALS

A. Piping materials to bear label, stamp, or other markings of specified testing agency.
B. 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.

### 2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

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

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings: Centrifugally cast gray cast iron pipe and static cast fittings conforming to requirements of ASTM Standard A 74, service weight (SV) type. Pipe and fittings marked with the collective trademark of the Cast Iron Soil Institute and listed by NSF® International.

C. Gaskets: ASTM C564, rubber.

D. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

### 2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

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

1. AB & I Foundry; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings: Centrifugally cast gray cast iron pipe and static cast fittings conforming to requirements of ASTM A 888 or CISPI 301. Pipe and fittings marked with the collective trademark of the Cast Iron Soil Institute and listed by NSF® International.

C. CISPI, Hubless-Piping Couplings:

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

   a. ANACO.
   b. Ideal Tridon Group.
   c. Mission Rubber Company, LLC; a division of MCP Industries.
   d. Tyler Pipe; a subsidiary of McWane Inc.

2. Standards: ASTM C1277 or CISPI 310.

3. Description: Standard stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, neoprene sleeve with integral, center pipe stop.

D. Heavy-Duty, Hubless-Piping Couplings:

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

   a. Husky SD4000.
   b. Clamp All 125.
   c. MG Products.

2. Standards: ASTM C1540.

3. Description: Type 304 stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, neoprene sleeve with integral, center pipe stop.

## 2.5 GALVANIZED-STEEL PIPE AND FITTINGS

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

1. U.S. Steel.
2. Wheatland Tube; Zekelman Industries.

B. Galvanized-Steel Pipe: ASTM A53/A53M, Type E, standard-weight cast iron. Include square-cut-grooved or threaded ends matching joining method.

C. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12, threaded.

D. Steel Pipe Pressure Fittings:

1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Schedule 40, seamless steel pipe. Include ends matching joining method.

2. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.

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

E. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:

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

a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
b. Shurjoint; a part of Aalberts Integrated piping Systems.
c. Smith-Cooper International.
d. Star Pipe Products.
e. Victaulic Company.

2. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A536, ductile-iron castings; ASTM A47/A47M, malleable-iron castings; ASTM A234/A234M, forged steel fittings; or ASTM A106/A106M, steel pipes with dimensions matching ASTM A53/A53M, steel pipe, and complying with AWWA C606 for grooved ends.

3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F1476, Type I. Include ferrous housing sections with continuous curved keys, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.

## 2.6 COPPER TUBE AND FITTINGS

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

1. Apollo Valves; a part of Aalberts Integrated Piping Systems.
2. Cambridge-Lee Industries, LLC.
3. Cerro Flow Products, LLC.
4. Wieland Copper Products, LLC.

B. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

C. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

D. Hard Copper Tube: ASTM B88, Type L and Type M, water tube, drawn temper.

E. Soft Copper Tube: ASTM B88, Type L, water tube, annealed temper.

F. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. 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.

G. Solder: ASTM B32, lead free with ASTM B813, water-flushable flux.

## 2.7 TRANSITION FITTINGS

A. Install transition couplings at joints of piping with small differences in OD's. Refer to transition fitting products specified in Section 22 05 00 “Common Work Results for Plumbing”.

## 2.8 DIELECTRIC FITTINGS

A. Dielectric Unions and Flanges: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Comply with requirements in Section 22 05 00 "Common Work Results for Plumbing."

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which drainage and vent systems, e.g., storm drainage, sanitary sewer, laboratory waste, etc., are to be installed in coordination with Installer of materials and components specified in this Section. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

1. Verify invert elevation of existing piping when new connections are indicated. Do not install buried sewer work until existing sewer invert elevation has been verified to meet required slope and bury depth requirements of new sewer piping.

2. Determine inverts and routing of piping systems and interferences with other building piping systems, building structure, lights, ductwork, foundations prior to installation.

B. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 20 00 "Earth Moving."

## 3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. 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 vent piping to allow application of insulation within 10 feet of a roof penetration.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. 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.

2. Use long-turn, double Y-branch, and 1/8-bend fittings if two fixtures are installed back-to-back or side-by-side with common drainpipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.

4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

    a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: Two percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
2. Horizontal Sanitary Waste Piping: Two percent downward in direction of flow.
3. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

N. Install steel piping in accordance with applicable plumbing code.

O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

P. Install force mains at elevations indicated.

Q. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
b. Comply with requirements for cleanouts specified in Section 22 13 19 "Sanitary Waste Piping Specialties."

2. Install drains in sanitary waste gravity-flow piping.

a. Comply with requirements for drains specified in Section 22 13 19 "Sanitary Waste Piping Specialties."

R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

S. Insulate vent piping within 10 feet of roof penetrations, all directions.

1. Comply with requirements for insulation specified in Section 22 07 19 " Plumbing Piping Insulation."

T. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

## 3.4 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.

C. Hubless, Cast-Iron Soil Piping Coupled Joints:

1. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.

1. Cut threads full and clean using sharp dies.

2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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

E. Join copper tube and fittings with soldered joints in accordance with ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

## 3.5 SPECIALTY PIPE FITTING INSTALLATION

A. Comply with requirements for transition fittings specified in Section 22 05 00 "Common Work Results for Plumbing."

B. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.

C. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

## 3.6 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping".

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install full-port ball valve for piping NPS 2 and smaller.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

## 3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment".

1. Install galvanized carbon-steel pipe hangers for horizontal piping in noncorrosive environments.

2. Install galvanized carbon-steel pipe support clamps for vertical piping in noncorrosive environments.

3. Vertical Piping: MSS Type 8 or Type 42 clamps.

4. Install individual, straight, horizontal piping runs:

   a. 100 Ft. and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Ft.: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Ft. if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Ft. or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze.

6. Base of Vertical Piping: MSS Type 52 spring hangers.

B. Install hangers for cast-iron steel and copper soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical runs of cast-iron steel and copper soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

## 3.8 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 waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste 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 waste and vent piping in sizes indicated, but not smaller than required by plumbing code.

4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

5. Comply with requirements for cleanouts and drains specified in Section 22 13 19 "Sanitary Waste Piping Specialties."

6. Equipment: Connect waste piping as indicated.

    a. Provide shutoff valve if indicated and union for each connection.
    b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections in accordance with 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.

## 3.9 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.
B. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

## 3.10 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 waste and vent piping in accordance with 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.

    a. 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 waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10 ft. head of water.
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    c. 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.

    a. 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.
    b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
    c. Air pressure must remain constant without introducing additional air throughout period of inspection.
    d. 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.

E. Test force-main piping in accordance with 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.

    a. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.

    a. Isolate test source and allow to stand for four hours.
    b. 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.

## 3.11 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.
B. Protect sanitary waste and vent piping 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.
D. Repair damage to adjacent materials caused by waste and vent piping installation.

## 3.12 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil, waste and vent piping NPS 3 and smaller are to be any of the following:

1. Service cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI 310, standard hubless-piping couplings; and coupled joints.
3. Copper Type DWV tube, copper drainage fittings, and soldered joints.
4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, soil, waste and vent piping NPS 4 and larger are to be any of the following:

1. Service cast iron, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground, soil, waste, and vent piping NPS 12 and smaller are to be any of the following:

1. Service cast-iron soil piping; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 are to be any of the following:

1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
2. Galvanized-steel pipe, pressure fittings, and threaded joints.

END OF SECTION 22 13 16

# SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Floor drains.
3. Miscellaneous sanitary drainage piping specialties.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:

1. Floor cleanouts, general building areas.
2. Wall cleanouts.
3. Floor drain "A".
4. Vent caps.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the "**As-Specified Verification Form**" (attached to Section 01 33 00 "Submittal Procedures") for each item listed below; otherwise submit full Product Data for the following:

1. Deep-seal traps.
2. Inline trap seal device

### 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts (CO):

1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping
3. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk or raised-head, brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Closure: Stainless steel plug with seal.

B. Floor Cleanouts, General Building Areas (CODP):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 4021-U Series or a comparable product by one of the following:

    a. Josam Company.
    b. MIFAB, Inc.
    c. WATTS; A Watts Water Technologies Company.
    d. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for adjustable housing cleanout.

3. Size: Same as connected branch.

4. Type: Adjustable threaded housing.

5. Body or Ferrule: Cast iron.

6. Outlet Connection: Spigot.

7. Closure: Brass plug with tapered threads or plastic plug and gasket.

8. Adjustable Housing Material: Nickel bronze with threads.

9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy with scoriated, vandal resistant top.

10. Frame and Cover Shape: Square.

11. Top-Loading Classification: Medium Duty.

12. Riser: ASTM A74, Service Class, cast-iron drainage pipe fitting and riser to cleanout.

C. Wall Cleanouts (COWP):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 4531-U Series or a comparable product by one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. WATTS; A Watts Water Technologies Company.
   d. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.

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, drilled-and-threaded bronze plug and gasket.

6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with vandal resistant screw.

## 2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains (FD "A"):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 2005 or a comparable product by one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. WATTS; A Watts Water Technologies Company.
   d. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.

3. Pattern: Floor drain.

4. Body Material: Gray iron.

5. Outlet: Bottom.

6. Backwater Valve: Not required.

7. Top of Body and Strainer Finish: Nickel bronze.

8. Top Shape: Square.

9. Dimensions of Top or Strainer: 7-inch square.

10. Top Loading Classification: Light Duty.

11. Trap Material: Cast iron.

12. Trap Pattern: Deep-seal P-trap.

13. Trap Features: Floor drain inline trap seal.

## 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, Inline Trap Seal:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; Quad Close Trap Seal No. 2962 or a comparable product by one of the following:

   a. Green Drain, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. RectorSeal Plumbing; A CSW Industrials Company.

2. Description: Inline floor drain trap seal, forming a physical barrier to slow trap evaporation while not impeding flow from drain.

3. Material: Polymer.

4. Standard: Tested and certified in accordance with ASSE 1072.

5. Listing: ICC-ES or IAPMO listed.

6. Size: Same as floor drain outlet or strainer throat.

C. Vent Caps:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Thaler Metal Industries Ltd; Model VPC Vandalproof Vent Stack Cap with perforated collar or comparable product by one of the following:

   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation

2. Description: Vandal-proof, .064" mill finish 1100 0T alloy aluminum vent stack cap with perforated collar, supporting cross member secured with vandal resistant stainless steel mounting screws.

3. Size: Same as connected stack vent or vent stack.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping 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.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. 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.

3. Set with grates depressed according to the following drainage area radii:

   a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
   b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.

c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

E. Install deep-seal traps on floor drains and other waste outlets, if indicated.

F. Install vent caps on each vent pipe passing through roof.

G. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

## 3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 22 13 16 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, to allow service and maintenance.

## 3.3 LABELING AND IDENTIFYING

A. 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.

1. Nameplates and signs are specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

## 3.4 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.

END OF SECTION 22 13 19

# SECTION 22 13 29 - SANITARY SEWERAGE PUMPS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Packaged wastewater-pump units.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

### 1.5 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

### 1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.
B. Protect bearings and couplings against damage.
C. Comply with pump manufacturer's written rigging instructions for handling.

### 1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

## 2.1 PACKAGED WASTEWATER-PUMP UNITS

A. Packaged, Submersible Wastewater-Pump Units:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Liberty Pumps; Model 405 or comparable product by one of the following:

   a. ABS Pumps Inc.; Sulzer Corporation.
   b. Bell & Gossett Domestic Pump; ITT Corporation.
   c. Goulds Pumps; ITT Corporation.
   d. Grundfos Pumps Corp.
   e. Little Giant Pump Co.
   f. McDonald, A. Y. Mfg. Co.
   g. Pentair Pump Group; Myers.
   h. Sta-Rite Industries, Inc.
   i. Zoeller Company.

2. Description: Factory-assembled and -tested, automatic-operation, effluent-pump unit with basin.

3. Pump Type: Submersible, end-suction, single-stage, overhung-impeller, centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.

4. Pump Body and Impeller: Corrosion-resistant materials.

5. Pump Seals: Mechanical.

6. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection.

7. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches and with grounding plug and cable-sealing assembly for connection at pump.

8. Control: Float switch.

9. Pump Discharge Piping: Factory or field fabricated, DWV copper.

10. Basin: Watertight plastic with inlet pipe connection and gastight cover with vent and pump discharge connections.

11. Capacities and Characteristics: Refer to Schedule on Drawings.

## 2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

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.

B. Motors for submersible pumps shall be hermetically sealed.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

### 3.2 INSTALLATION

A. Pump Installation Standards:

1. Comply with HI 1.4 for installation of centrifugal pumps.

B. Wiring Method: Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

### 3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 13 16 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment to allow service and maintenance.

### 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. 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. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system 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.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

## 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.

## 3.6 ADJUSTING

A. Adjust pumps to function smoothly and lubricate as recommended by manufacturer.
B. Adjust control set points.

## 3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 22 13 29

# SECTION 22 16 23 - FACILITY NATURAL-GAS PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Concrete bases.

### 1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.

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

D. 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.

### 1.4 ACTION SUBMITTALS

A. Product Data:

1. Piping and specialties.
2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Dielectric fittings.

## 1.5 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Submittals:

1. Field quality-control reports.

## 1.6 QUALITY ASSURANCE

A. Qualifications:

1. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

B. Regulatory Requirements:

1. Install gas equipment, piping materials and provide testing in accordance with Fuel Gas Code of New York State, applicable American National Standards Institute (ANSI) code and NFPA 54 - National Fuel Gas Code, and rules and regulations of local gas company.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with 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.

## 1.8 PROJECT CONDITIONS

A. Interruption of Existing Natural-Gas Service: Refer to “Existing Utility Interruptions” paragraph of Section 01 12 00 “Multiple Contract Summary-Project Schedule” for requirements associated with interrupting the existing natural gas supply to facilities occupied by the Owner.

## 1.9 COORDINATION

A. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 22 05 53 "Identification of Plumbing Piping and Equipment."

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each product type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Comply with the Fuel Gas Code of New York State.

B. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

C. Natural-Gas System Pressure within Buildings:

1. Single Pressure: 0.5 psig or less.

2.3 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, 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 A 234/A 234M 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. 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.

b. Stainless steel flanges and tube with epoxy finish.

c. NBR seals.

d. Stainless steel bolts, washers, and nuts.

e. Coupling is to 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 are to be factory equipped with anode.

## 2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.
B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

## 2.5 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. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.

6. Service Mark: Valves NPS 1-1/4 to NPS 2 having 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" permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model T-585-70-UL or comparable product by one of 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.

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 are to 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.

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 are to 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, 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. A.Y. McDonald Mfg. Co.
   b. Flowserve Corporation.
   c. Homestead Valve, a division of Olson Technologies, Inc.
   d. Milliken Valve Company; a Mueller brand.
   e. Mueller Co.
   f. R & M Energy Systems; Robbins & Myers.

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 are to 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.

## 2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Refer to Section 22 05 00 "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

## 2.7 LABELING AND IDENTIFYING

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53 "Identification for Plumbing Piping and Equipment."
B. Paint: Refer to Section 09 96 00 "High-Performance Coatings" for interior and exterior natural-gas piping paint materials and basic installation requirements.

# 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 Fuel Gas Code of New York State to determine that natural-gas utilization devices are turned off in piping section affected.
C. Comply with Fuel Gas Code of New York State requirements for prevention of accidental ignition.

## 3.3 INSTALLATION OF OUTDOOR PIPING

A. Comply with Fuel Gas Code of New York State for installation and purging of natural-gas piping.
B. Install fittings for changes in direction and branch connections.

## 3.4 INSTALLATION OF INDOOR PIPING

A. Comply with Fuel Gas Code of New York State 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. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.

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. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.

G. Locate valves for easy access. Do not locate valves within return air plenums.

H. Install piping free of sags and bends.

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

J. Verify final equipment locations for roughing-in.

K. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

L. 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 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

M. 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.

N. 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 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.

3. 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.

O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

P. Connect branch piping from top or side of horizontal piping.

Q. 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.

R. Do not use natural-gas piping as grounding electrode.

S. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

## 3.5 INSTALLATION OF VALVES

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
B. Do not install valves in return-air plenums.

## 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 in accordance with AWS D10.12/D10.12M, 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. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

## 3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for hangers, supports, and anchor devices.

B. Install hangers for steel piping with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

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.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

## 3.8 PIPING CONNECTIONS

A. Install natural-gas piping electrically continuous and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.

B. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.

C. 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.

## 3.9 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for piping and valve identification.

## 3.10 PAINTING

A. Comply with requirements in Section 09 96 00 “High-Performance Coatings” 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.

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.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

## 3.11 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Test, inspect, and purge natural gas according to Fuel Gas Code of New York State and authorities having jurisdiction.

   a. Isolate appliances and equipment prior to conducting pressure test.

   b. The test medium shall be air, nitrogen, carbon dioxide or an inert gas. Oxygen shall not be used.

   c. Leave pipe joints, including welds, exposed for examination during the test.

   d. Isolate the source of pressure before the pressure tests are made.

   e. Measure test pressure with a manometer or with a pressure-measuring device designed and calibrated to read, record or indicate a pressure loss caused by leakage during the pressure test period. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than five times the test pressure.

   f. Pressure test piping to no less than 1-1/2 times the proposed maximum working pressure, but not less than 30-psig irrespective of delivered gas pressure, for a duration of 2 hours.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.12 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping NPS 2 and smaller shall be one of the following:

1. ASTM A53 / A53M steel pipe with malleable-iron fittings and threaded joints.
2. ASTM A53 / A53M steel pipe with wrought-steel fittings and welded joints.

B. Aboveground natural-gas piping NPS 2 1/2 and larger shall be the following:

1. ASTM A53 / A53M steel pipe with wrought-steel fittings and welded joints.

## 3.13 INDOOR PIPING SCHEDULE

A. Aboveground piping NPS 2 and smaller shall be one of the following:

1. ASTM A53 / A53M steel pipe with malleable-iron fittings and threaded joints.
2. ASTM A53 / A53M steel pipe with wrought-steel fittings and welded joints.

B. Aboveground, distribution piping NPS 2 1/2 and larger shall be the following:

1. ASTM A53 / A53M steel pipe with wrought-steel fittings and welded joints.

## 3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger shall be the following:

1. Cast-iron, non-lubricated plug valve.

END OF SECTION 22 16 23

# SECTION 22 42 16.16 - COMMERCIAL SINKS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sinks.
2. Sink faucets.
3. Supply fittings.
4. Waste fittings.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.

2. Include rated capacities, operating characteristics and furnished specialties and accessories.

a. Sink “A” faucet.
b. Sink “B” faucet.
c. Sink “C” faucet.
d. Sink “D” faucet.
e. Sink “E” faucet.
f. Sink “F” faucet.

B. As-Specified Data: If the product to be incorporated in the Work is as specified by manufacturer name and product designation in this Specification Section, submit the “**As-Specified Verification Form**” (attached to Section 01 33 00 “Submittal Procedures”) for each item listed below; otherwise submit full Product Data for the following:

1. Sink “A” bowl.
2. Sink “B” bowl.
3. Sink “C” bowl.
4. Sink “D” bowl.
5. Sink “E” bowl.
6. Sink “F” bowl.
7. Supply Fittings.
8. Drain Fitting.
9. Offset Drain Fitting.

10. Dishwasher Tailpiece.
11. Continuous Waste Fittings.
12. Sink Traps.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks and accessories to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Water Conservation:

1. Provide plumbing fixtures complying with applicable provisions of Section 604.4 of the Plumbing Code of New York State, including the 2017 Uniform Code Supplement.

B. NSF Compliance:

1. NSF/ANSI-61- Drinking Water System Components - Health Effects.
2. NSF/ANSI-372 for lead-free valve materials for potable-water service.

C. Regulatory Requirements: Comply with requirements in 36 CFR Part 1191 – “Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines"; for plumbing fixtures for people with disabilities.

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.

1. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
2. Science Faucet Outlets: Full flow serrated nozzles equal to 75 percent of amount of each type and size science faucet installed.

PART 2 - PRODUCTS

2.1 SINKS

A. Sink “A”: Standard stainless steel, counter mounted, accessible.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model No. LRAD2521-55 or comparable product by one of the following:

a. Advance Tabco.
b. Eagle Group; Foodservice Equipment Division.
c. Griffin Products, Inc.
d. Just Manufacturing.

2. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.

b. Type: Ledge back.

c. Number of Compartments: One.

d. Overall Dimensions: 25 by 21.25 inches.

e. Metal Thickness: 18 gauge / 0.050 inch.

f. Material: Type 304 stainless steel with fully undercoated underside.

g. Compartment:

1) Dimensions: 21 by 15.75 by 5.5 inches.
2) Drain: 3.5-inch opening.
3) Drain Location: Centered, near back of compartment.

3. Faucet(s): Accessible manual type, single-control mixing valve with swing spout. Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On sink fixture ledge, in hole(s) provided.

4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

5. Waste Fittings: Offset Drain Fitting. Comply with requirements in "Drains" Article.

6. Traps: Sink Trap. Comply with requirements in "Traps" Article.

7. Mounting: On counter with manufacturer recommended sealant.

B. Sink “B”: Stainless steel, counter mounted, double bowl.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model No. LR 3321 or comparable product by one of the following:

a. Advance Tabco.
b. Eagle Group; Foodservice Equipment Division.
c. Griffin Products, Inc.
d. Just Manufacturing.

2. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.

b. Type: Ledge back.

c. Number of Compartments: Two.

d. Overall Dimensions: 33 by 21.25 inches.

e. Metal Thickness: 18 gauge / 0.050 inch.

f. Material: Type 304 stainless steel with fully undercoated underside.

g. Each Compartment:

1) Dimensions: 28 by 16 by 7.875 inches.
2) Drain: 3.5-inch openings.
3) Drain Location: Centered.

3. Faucet(s): Accessible manual type, single-control mixing valve with swing spout.Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On sink fixture ledge, in hole(s) provided.

4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

5. Waste Fittings: Drain Fittings and Continuous Waste Fitting. Comply with requirements in "Drains" Article.

6. Traps: Sink Trap. Comply with requirements in "Traps" Article.

7. Mounting: On counter with manufacturer recommended sealant.

C. Sink “C”: Stainless steel, counter mounted, double bowl, accessible.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model No. LRAD 3321-55 or comparable product by one of the following:

a. Advance Tabco.
b. Eagle Group; Foodservice Equipment Division.
c. Griffin Products, Inc.
d. Just Manufacturing.

2. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.

b. Type: Ledge back.

c. Number of Compartments: Two.

d. Overall Dimensions: 33 by 21.25 inches.

e. Metal Thickness: 18 gauge / 0.050 inch.

f. Material: Type 304 stainless steel with fully undercoated underside.

g. Each Compartment:

1) Dimensions: 13.5 by 16 by 5.5 inches.
2) Drain: 3.5-inch openings.
3) Drain Location: Centered, near back of compartments.

3. Faucet(s): Accessible manual type, single-control mixing valve with swing spout.Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On sink fixture ledge, in hole(s) provided.

4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

5. Waste Fittings: Offset Drain Fittings and Continuous Waste Fitting. Comply with requirements in "Drains" Article.

6. Traps: Sink Trap. Comply with requirements in "Traps" Article.

7. Mounting: On counter with manufacturer recommended sealant.

D. Sink “D”: Science sink with single hole, two-cross-handle faucet.

1. Fixture: Refer to Specification Section 12 32 13 “Manufactured Wood-Veneer-Faced Casework” for science sink bowls.

2. Faucet(s): Manual type, single hole, two-cross-handle mixing valve science sink faucet. Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On countertop, in hole provided.

3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

4. Waste Fittings: PP Sink Outlets. Comply with requirements for chemical resistant waste fittings specified in Section 22 66 00 "Chemical-Waste Systems for Laboratory Facilities."

5. Traps: Corrosion-Resistant Traps. Comply with requirements for chemical resistant traps specified in Section 22 66 00 "Chemical-Waste Systems for Laboratory Facilities."

E. Sink “E”: Accessible science sink with single hole, wrist-blade-handle faucet.

1. Fixture: Refer to Specification Section 12 32 13 “Manufactured Wood-Veneer-Faced Casework” for science sink bowls.

2. Faucet(s): Accessible, manual type, single hole, wrist-blade-handle mixing valve science sink faucet. Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On countertop, in hole provided.

3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

4. Waste Fittings: PP Sink Outlets. Comply with requirements for chemical resistant waste fittings specified in Section 22 66 00 "Chemical-Waste Systems for Laboratory Facilities."

5. Traps: Corrosion-Resistant Traps. Comply with requirements for chemical resistant traps specified in Section 22 66 00 "Chemical-Waste Systems for Laboratory Facilities."

F. Sink “F”: Stainless steel, counter mounted, double bowl with dishwasher tailpiece.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model No. LR 3321 or comparable product by one of the following:

a. Advance Tabco.
b. Eagle Group; Foodservice Equipment Division.
c. Griffin Products, Inc.
d. Just Manufacturing.

2. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.

b. Type: Ledge back.

c. Number of Compartments: Two.

d. Overall Dimensions: 33 by 21.25 inches.

e. Metal Thickness: 18 gauge / 0.050 inch.

f. Material: Type 304 stainless steel with fully undercoated underside.

g. Each Compartment:

1) Dimensions: 28 by 16 by 7.875 inches.
2) Drain: 3.5-inch openings.
3) Drain Location: Centered.

3. Faucet(s): Accessible manual type, single-control mixing valve with swing spout.Comply with requirements in “Sink Faucet” Article.

a. Number Required: One.
b. Mounting: On sink fixture ledge, in hole(s) provided.

4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

5. Waste Fittings: Drain Fittings, Dishwasher Tailpiece and Continuous Waste Fitting. Comply with requirements in "Drains" Article.

6. Traps: Sink Trap. Comply with requirements in "Traps" Article.

7. Mounting: On counter with manufacturer recommended sealant.

## 2.2 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Accessible manual type, single-control mixing valve with swing spout.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model LK1000CR or comparable product by one of the following:

   a. American Standard America.
   b. Bradley Corporation.
   c. Chicago Faucets.
   d. Delta Faucet Company.
   e. Elkay Manufacturing Co.
   f. GROHE America, Inc.
   g. Just Manufacturing.
   h. Kohler Co.
   i. Moen Incorporated.
   j. Speakman Company.
   k. T & S Brass and Bronze Works, Inc.
   l. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASME A112.18.1/CSA B125.1.

3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.

4. Body Type: Widespread.

5. Body Material: General-duty, solid brass.

6. Finish: Chrome plated.

7. Maximum Flow Rate: 2.2 gpm.

8. Handle(s): Lever.

9. Mounting Type: Deck, exposed.

10. Spout Type: Swing, shaped tube.

11. Spout Outlet: Aerator.

C. Science Sink Faucets: Accessible, manual type, single hole, wrist-blade-handle mixing valve.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Chicago Faucets; Model No. 930-VR317CP-E3-2JKCP or comparable product by one of the following:

    a. Delta Faucet Company.
    b. GROHE America, Inc.
    c. Just Manufacturing.
    d. Moen Incorporated.
    e. Speakman Company.
    f. T & S Brass and Bronze Works, Inc.
    g. Zurn Plumbing Products Group.

2. Standard: ASME A112.18.1/CSA B125.1/ADA ANSI/ICC A117.1.

3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.

4. Body Type: Single hole with anti-rotational body deck pin.

5. Body Material: Commercial, solid brass.

6. Finish: Chrome plated.

7. Maximum Flow Rate: 2.2 gpm.

8. Handle(s): Wrist blade, 4 inches.

9. Mounting Type: Deck, exposed.

10. Spout Type: 6-inch rigid gooseneck with integral vacuum breaker.

11. Spout Outlet: Pressure compensating aerator with spout adapter design.

D. Science Sink Faucets: Manual type, single hole, two-cross-handle mixing valve.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Chicago Faucets; Model No. 930-VRCP-E3-2JKCP or comparable product by one of the following:

    a. Delta Faucet Company.
    b. GROHE America, Inc.
    c. Just Manufacturing.
    d. Moen Incorporated.
    e. Speakman Company.
    f. T & S Brass and Bronze Works, Inc.
    g. Zurn Plumbing Products Group.

2. Standard: ASME A112.18.1/CSA B125.1.

3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.

4. Body Type: Single hole with anti-rotational body deck pin.

5. Body Material: Commercial, solid brass.

6. Finish: Chrome plated.

7. Maximum Flow Rate: 2.2 gpm.

8. Handle(s): Cross, four arm.

9. Mounting Type: Deck, exposed.

10. Spout Type: 6-inch rigid gooseneck with integral vacuum breaker.

11. Spout Outlet: Pressure compensating aerator with spout adapter design.

E. Science Faucets: Serrated nozzles.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Chicago Faucets; Model No. E7JKCP or comparable product by one of the following:

a. Delta Faucet Company.
b. GROHE America, Inc.
c. Just Manufacturing.
d. Moen Incorporated.
e. Speakman Company.
f. T & S Brass and Bronze Works, Inc.

2. Chrome plated.

3. 3/8 inch - 18 NPSM male inlet.

4. 10 serrations for typical Laboratory Hoses.

## 2.3 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc. No. LF2167-F or comparable product by one of the following:

1. American Standard America
2. Zurn Industries, LLC; Commercial Brass and Fixtures.

C. Standard: ASME A112.18.1/CSA B125.1.

D. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass escutcheon with set screw.

E. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

F. Operation: Wheel handle.

G. Risers:

1. NPS 1/2.
2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

## 2.4 DRAINS

A. Drain Fitting:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co No. LK35 or comparable product by one of the following:

a. Just Manufacturing.
b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASME A112.18.2/CSA B125.2.

3. Drain: Conical basket strainer with removable stopper and chrome plated brass NPS 1-1/2 by 4 inch tailpiece.

4. Material: Stainless steel body with polished finish.

B. Offset Drain Fitting:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co No. LK35L or comparable product by one of the following:

a. Just Manufacturing.
b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASME A112.18.2/CSA B125.2.

3. Drain: Conical basket strainer with removable stopper and NPS 1-1/2-inch chrome plated brass 90° elbow.

4. Material: Stainless steel body with polished finish.

C. Dishwasher Tailpiece:

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. Dearborn Brass.
b. ROC Industries, Inc.
c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.

2. Standard: ASME A112.18.2/CSA B125.2.

3. Material: Chrome plated 17-gauge seamless brass tailpiece with 3/4-inchdishwasher connection and cast brass nuts.

D. Continuous Waste Fittings:

1. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc. No. 111C16G17 or comparable product by one of the following:

a. American Standard America.
b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Standard: ASME A112.18.2/CSA B125.2.

3. Material: End outlet continuous waste with satin plated cast brass tee, chrome plated 17-gauge seamless brass waste arms, brass tailpiece and cast brass nuts.

4. Size: NPS 1-1/2 by NPS 1-1/2.

## 2.5 TRAPS

A. Sink Traps:

1. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc. No. 8912-F or comparable product by one of the following:

a. American Standard America.
b. Zurn Industries, LLC; Commercial Brass and Fixtures.

2. Material: Chrome-plated, two-piece, cast-brass trap and ground-joint swivel elbow, 17-gauge brass tube to wall with cleanout plug. Include chrome-plated brass escutcheon with set screw.

3. Standard: ASME A112.18.2/CSA B125.2.

4. Size: NPS 1-1/2 by 1-1/2.

# 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 sink installation.
B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.
D. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Install water-supply piping with stop on each supply to each sink faucet.

1. Install stops in locations where they can be easily reached for operation.

E. Install wall flanges or escutcheons at piping wall penetrations and casework penetrations. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

F. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants" and sink manufacturer's recommendations.

## 3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."
C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

## 3.4 FIELD QUALITY CONTROL

A. Inspecting Agency: Owner will engage a qualified laboratory to perform lead testing on all potable water faucets installed under this contract and used or potentially used for drinking or cooking purposes according to NYS Law 10 CRR-NY 67-4.1. Test results will be submitted to the Owner, Contractor and the Architect.

B. Replace any faucet that exceeds the lead action level (5 micrograms per liter) and coordinate with the Owner for retesting until satisfactory results are obtained.

## 3.5 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
B. Adjust water pressure at faucets to produce proper flow.

## 3.6 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.
B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
C. Provide protective covering for installed sinks and fittings.
D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 42 16.16

# SECTION 22 45 00 - EMERGENCY PLUMBING FIXTURES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Water-tempering equipment.

### 1.2 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
C. Tepid: Between 60 and 100 deg F.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

1. Hot-and cold-water, water-tempering equipment – EM TMV “A”.

B. Shop Drawings:

1. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

### 1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Submittals:

1. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI/ISEA Z358.1 for emergency plumbing fixtures including third-party certification of fixtures.
B. Comply with ASSE 1071 for temperature-actuated mixing valves for plumbed emergency fixtures.
C. Comply with ASME A112.18.1/CSA B125.1 for water-supply fittings.
D. Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.
E. Comply with NSF 61 and NSF 372 for fixture materials that will be in contact with potable water.

2.2 WATER-TEMPERING EQUIPMENT

A. Shower Hot- and Cold-Water, Water-Tempering Equipment – EM TMV "A":

1. Basis-of-Design Product: Subject to compliance with requirements, provide Bradley Corporation; Navigator No. S19-2250 (EFX50) or comparable product by one of the following:

a. Armstrong International, Inc.
b. Haws Corporation.
c. Lawler Manufacturing Co., Inc.
d. Speakman Company.

2. Description: Factory-fabricated equipment with thermostatic mixing valve.

a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus3 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping.

3. Pressure Rating: 125 psig.

4. Type: Exposed-mounted, compact body design, thermostatically controlled, emergency fixture thermostatic mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded inlets and outlet.

7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Valve Finish: Rough bronze.

9. Piping Finish: Copper.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

### 3.2 INSTALLATON OF EMERGENCY PLUMBING FIXTURE

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping."

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 22 11 16 "Domestic Water Piping."

F. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

G. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

### 3.3 PIPING CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 22 11 16 "Domestic Water Piping."

B. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

C. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

## 3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

B. Install valve function signage on isolation valves serving emergency fixtures. Comply with requirements for identification materials specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

## 3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.6 ADJUSTING

A. Operate and adjust emergency plumbing fixtures and controls. Replace damaged and malfunctioning fixtures and controls.
B. Adjust or replace fixture flow regulators for proper flow.
C. Adjust equipment temperature settings.

## 3.7 CLEANING AND PROTECTION

A. Clean emergency plumbing fixtures with manufacturers' recommended cleaning methods and materials.
B. Install protective covering for installed emergency plumbing fixtures and fittings.
C. Do not allow use of emergency plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 45 00

# SECTION 22 66 00 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY FACILITIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Single-wall piping.
2. Piping specialties.

### 1.3 DEFINITIONS

A. FPM: Vinylidene fluoride (hexafluoropropylene copolymer rubber).

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. PP drainage pipe and fittings
2. Adapters and transition fittings
3. Plastic dilution traps
4. PP sink outlets

### 1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

### 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks to include in emergency, operation, and maintenance manuals.

### 1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
B. Do not store plastic pipe or fittings in direct sunlight.
C. Protect pipe, fittings, and seals from dirt and damage.

1.8 FIELD CONDITIONS

A. Interruption of Existing Chemical-Waste Service: Refer toSection 01 12 00 “Multiple Contract Summary-Project Schedule” for interruption of existing chemical-waste service requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet headof water for 30 minutes.

2.2 SINGLE-WALL PIPE AND FITTINGS

A. PP Drainage Pipe and Fittings: ASTM F1412, extruded pipe and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D 4101; with mechanical-joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.

2. Basis-of-Design Product: Subject to compliance with requirements, provide IPEX USA LLC ; Enfield / Labline. or a comparable product by one of the following:

a. GF Piping Systems: Georg Fischer LLC.
b. Orion Fittings; A WATTS Brand.

3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.

4. Mechanical Fittings: Integrally molded union designed to lock into a groove machined into mating pipe.

B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.3 JOINING MATERIALS

A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

## 2.4 PIPING SPECIALTIES

A. Plastic Dilution Traps:

1. Basis-of-Design Product: Subject to compliance with requirements, provide IPEX USA LLC ; Enfield / Labline. or a comparable product by one of the following:

    a. GF Piping Systems: Georg Fischer LLC.
    b. Orion Fittings; A WATTS Brand.
    c. Town & Country Plastics, Inc.
    d. Zurn Industries, LLC.

2. Source Limitations: Obtain traps from single source from single manufacturer.

3. Material: Corrosion-resistant PP, with removable base.

4. End Connections: Mechanical joint.

5. Dilution Tanks: 1-gal. capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 top inlets and one NPS 1-1/2 side outlet.

B. PP Sink Outlets:

1. Description: NPS 1-1/2, with clamping device, stopper, and 7-inch-high overflow fitting.

# PART 3 - EXECUTION

## 3.1 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:

1. Install piping adjacent to equipment, accessories, and specialties, to allow space for service and maintenance.

2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.

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

4. 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.

5. Install piping at indicated slopes.

6. Install piping free of sags and bends.

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

8. Verify final equipment locations for roughing-in.

9. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

10. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

11. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

## 3.2 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building (except exposed piping in casework):

1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints in accordance with ASTM F1290.
2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

## 3.3 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground single-wall piping.

B. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or MSS Type 42 riser clamps.

2. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

3. Base of Vertical Piping: MSS Type 52 spring hangers.

C. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

D. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

E. Support vertical piping and tubing at base and at each floor.

F. Rod diameter may be reduced one size for double-rod hangers, to minimum of 3/8 inch.

G. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 33 inches with 3/8-inch rod.
2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.

H. Install supports for vertical PP piping every 72 inches.

I. Support piping and tubing not listed above in accordance with MSS SP-58.

## 3.4 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Make connections to existing piping, so finished Work complies as nearly as practical with requirements specified for new Work.
C. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
D. Where installing piping adjacent to equipment, allow space for service and maintenance.

## 3.5 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

## 3.6 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.

b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.

c. Crushed, broken, cracked, or otherwise damaged piping.

d. Hydrostatic Tests for Drainage Piping:

1) Close openings in system and fill with water.
2) Purge air and refill with water.

3) Disconnect water supply.
4) Test and inspect joints for leaks.

e. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.

3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials and repeat testing until no leaks exist.

C. Perform tests and inspections with the assistance of a factory-authorized service representative:

D. 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.

E. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

## 3.7 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PP drainage pipe and fittings and fusion joints.

C. Exposed Chemical-Waste Piping in Casework: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 3: PP drainage piping and mechanical joints.

D. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.

END OF SECTION 22 66 00

# SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and all Division 01 Sections, apply to this Section and to all of Division 23.

### 1.2 SUMMARY

A. This Section includes the following:

1. Definitions, references, and abbreviations.
2. General regulatory requirements.
3. General requirements regarding site/field conditions including existing conditions and field measurements.
4. Sequencing and scheduling including coordination.
5. Definition of design equipment and procedures for consideration of specified equivalents, proposed equivalents, or substitutions.
6. HVAC demolition.
7. Equipment installation requirements common to equipment sections.
8. Minimum material requirements and equipment verification.
9. Electrical components for HVAC Work
10. Painting and finishing.
11. General requirements for demonstration of completed systems

### 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. "Design Equipment", "Design Make", "Basis of Design", and similar terms: Equipment, specified in Technical Specification Section or on Contract Drawings using applicable manufacturer's designation, that forms the basis for performance requirements, physical dimensions, configuration, electrical connection requirements, and similar aspects used in the design of this Project including (but not limited to) physical configuration of surrounding construction and location of connections to other components.

G. Specified Equivalents: Products identified in Technical Specification Section that may provide performance complying with specified requirements but may not have the same arrangement, configuration, size, construction, or other aspects as the specified Design Equipment. Refer to Section 00 21 13 - Instructions to Bidders, and Section 01 25 00 – Substitution Procedures for additional information and requirements regarding equivalents and substitutions.

H. "Equivalents", "Proposed Equivalents", "Proposed Products" and similar terms: These terms may be used interchangeably and mean the same thing: Products NOT identified in Technical Specification Section that the Contractor proposes in accordance with Section 00 21 13 - Instructions to Bidders and Section 01 25 00 – Substitution Procedures.

I. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor, all in accordance with Section 01 25 00 – Substitution Procedures.

J. Heating Work: Refers to Heating, Ventilating and Air Conditioning Systems and Equipment where used in technical specification sections of Division 23.

## 1.4 ABBREVIATIONS

A. Abbreviations: Reference to technical society, organization, body or section made in Division 23 in accordance with the following abbreviations:

| | | |
|---|---|---|
| 1. | AIA | American Institute of Architects |
| 2. | ADA | Americans with Disabilities Act. |
| 3. | AMCA | Air Movement and Control Association International, Inc. |
| 4. | ANSI | American National Standards Institute |
| 5. | ASHRAE | American Society of Heating, Refrigerating and Air Conditioning Engineers |
| 6. | ASME | American Society of Mechanical Engineers International |
| 7. | ASTM | American Society for Testing and Materials International |
| 8. | AWS | American Welding Society |
| 9. | IBC | International Building Code, New Jersey Edition |
| 10. | IEEE | Institute of Electrical and Electronics Engineers, Inc. |
| 11. | NEC | National Electric Code |
| 12. | NEMA | National Electrical Manufacturers Association |
| 13. | NFPA | National Fire Protection Association |
| 14. | NYBFU | New York Board of Fire Underwriters |
| 15. | SMACNA | Sheet Metal and Air Conditioning Contractors National Association |
| 16. | UL | Underwriters Laboratories Inc. |

## 1.5 SYSTEM DESCRIPTION

A. Provide complete systems, properly connected, tested, balanced, adjusted, and ready for operation, including all necessary and required controls, safeties, details and accessories, including (but not limited to):

1. Demolition and removals required for equipment and system installation.
2. Piping systems and related equipment.
3. Ventilation systems and related equipment.
4. Support Systems and related equipment.
5. Insulation Systems and related equipment.
6. Miscellaneous items required for equipment and system installation.
7. Controls and electrical control wiring to equipment furnished in this contract.
8. Electrical power wiring to equipment furnished in this contract, where not covered elsewhere.

B. HEATING WORK DRAWINGS ARE DIAGRAMMATIC. Do not infer that Drawings show level of detail indicating every offset, elbow, union, fitting, elevation or aspect ratio changes, or other details required for complete installation.

1. Provide all required fittings, offsets, elevation changes, dampers, controls, components, and similar items not indicated on Drawings, as required for a complete properly operational system.

## 1.6 SUBMITTALS

A. General Division 23 submittal requirements:

1. Procedural Requirements: Comply with requirements of Section 01 33 00 - Submittals and as modified below.

a. Specified Products: If product to be incorporated into Project is the basis of design equipment, and will be installed as specified in Part 3 in the product's technical specification section, and only where allowed as such in submittal portion of product specification, then the "As-Specified Verification Form" (attached to Section 01 33 00 - Submittals) may be used in lieu of "Product Data" identified.

b. Do not use "As Specified Verification Form" unless specifically indicated in detailed product specification.

c. Equivalent Products or Substitutions: If product proposed to be incorporated into Project is <u>not</u> the basis of design equipment, comply with all Product Data requirements specified.

2. Product Data: Submit Product Data for items listed in individual technical section. Clearly identify manufacturer, pertinent design, function, materials, construction, and performance data specifically addressing specification description and Contract Document requirements of item. Where more than one product is indicated on manufacturer product literature, strike out products that are not applicable to item being submitted, highlight options selected and proposed, and remove extraneous pages of catalogs not being used in the project..

    a. Cover Sheet: Attach cover sheet, identified in Section 01 33 00, to Product Data of each item submitted. Provide cover sheet for only one type of item with related accessories, equipment with related components. Do not combine unrelated items under same cover sheet.

    b. Specified Equivalent Product Data: Submit manufacturer's product information including product literature, technical specifications and descriptions, performance data, and similar items to demonstrate compatibility with Basis-of-Design Equipment as specified in "Manufacturers" in Part 2 - Products below.

3. Coordination Drawings: Prepare Coordination Drawings in timely manner to comply with overall construction schedule. Refer to Sections 01 31 00 and 01 33 00 for more details.

    a. Prepare drawings coordinating HVAC systems, lighting fixtures, ceiling mounted devices, ceiling heights, materials, structural work, maintenance clearances, electric code clearance, building systems, existing construction, etc. Provide additional details and sections, as required for clarity, at all places of potential conflict.

    b. Deliver Coordination Drawings in accordance with requirements specified in Section 01 31 00. Indicate areas of conflicts between HVAC systems and other building components by highlighting locations on drawings and separately listing.

    c. Reposition proposed locations of HVAC systems as required to work within project constraints. Adjust exact size, aspect ratio, location and offsets of ducts and pipes as required. Achieve as specified and other reasonable appearance objectives in open areas without ceilings without increase in Contract Sum.

    d. Review of Coordination Drawings in accordance with Section 01 31 00 does not relieve Contractor from responsibility for coordinating HVAC systems with Project work, nor does it authorize extra cost, omission or deviation from Contract Document requirements. Costs arising from errors or omissions in Coordination Drawings shall be borne by Contractor.

    e. Review Coordination Drawings and compare them with all other drawings to verify that all Work can be installed without interference. Notify Owner's Project Representative in case of unresolved interferences prior to installation of any work. Revise Coordination Drawings as required to eliminate installation interferences upon direction of Architect.

f. Do not proceed with installation of systems in each area until agreement is reached with all concerned on exact arrangements for each room or area, unless otherwise directed by Architect. If Contractor proceeds prior to resolving conflicts, Contractor shall modify installed Work as required to permit other systems to proceed with a coordinated installation.

4. Specified Equivalent Drawings: Submit detailed drawings of proposed Specified Equivalents, indicating proposed installation of equipment and showing maintenance clearances, required service removal space, and other pertinent revisions to arrangement and configuration shown in Contract Documents.

5. Closeout Information, for inclusion in Operations and Maintenance Manual:

a. Approved submittals.

1) If "As-Specified Verification Form" submittal is approved, also include product data as specified in technical section for all components used.

b. Include all information required in Section 01 78 23 – Operation and Maintenance Data.

c. Include all other closeout information required by the individual technical specification sections.

B. Shop Drawings: Include dimensioned plans, sections, and attachments to other work for concrete bases.

C. Closeout Information, for inclusion in Operations and Maintenance Manual:

1. Approved submittals.

a. If "As-Specified Verification Form" submittal is approved, also include product data for all components used.

2. Include all information required in Section 01 78 23 – Operation and Maintenance Data.

3. Letters on manufacturer's letterhead from equipment manufacturers certifying that their equipment and systems have been installed in strict accordance with manufacturer's recommendations, properly aligned and adjusted, tested, lubricated, wired, balanced, etc.

4. Valve, Lubrication, and Filter charts as described below.

## 1.7 QUALITY ASSURANCE

A. Regulatory Requirements

1. Comply with applicable requirements of all Federal, New York State, and Local Building, Health, Mechanical, Plumbing and Electrical Codes, Laws, Ordinances and Regulations, including (but not limited to):

a. Building Code of New York State

b. Mechanical Code of New York State
c. Fire Code of New York State
d. Energy Conservation Construction Code of New York State
e. New York State Education Department Manual of Planning Standards
f. In event of a conflict between the Codes identified above and Contract Documents, comply with more stringent requirement.

2. Comply with applicable requirements of NFPA, utility company regulations, and following standards:

a. Provide Underwriters Laboratories (UL) labels on all electrical materials carrying 50 volts or more.
b. Provide refrigeration equipment complying with Safety Code for Mechanical Refrigeration (ASHRAE Standard 15 - and ANSI Refrigeration Safety Code B9.1).

B. Certifications: Obtain and pay for all necessary inspections and certificates from all applicable agencies. Perform all required tests in accordance with regulation of agency having jurisdiction. Submit certificates of approval prior to Final Completion as defined in Section 01 77 00 – Closeout Procedures. Submit certificates of approval prior to request for final acceptance of Contract.

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 at no additional cost to the Owner. Equipment must continue to comply with the requirements of the Energy Conservation Code applicable to the project.

D. Welding Quality Control for General Construction and Support Work:

1. This paragraph refers to qualifications for General Construction and Support Work welding only. Qualify welders, brazers, and any welding or brazing procedure to be used on piping for this Project in accordance with ASME "Boiler and Pressure Vessel Code", Section IX, as specified and detailed in Section 23 21 13 - Hydronic Piping.

2. Welding and Brazing Procedure Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel." Qualification may by made by technically competent group or agency (subject to approval) meeting the following conditions:

a. Group or agency qualifying the procedure meets all procedure qualification requirements of AWS D1.1/D1.1M, "Structural Welding Code - Steel.".

b. Contractor accepts full responsibility for procedure qualified.

c. Contractor has qualified at least one welder or welding operator using procedure qualified and provides record of qualification.

d. Contractor accepts full responsibility for qualified procedures by signing related qualification records with procedure and performance qualifications including all dates, results, and associated data.

3. Welders' and Brazers' Qualifications: Ensure that all welders, welding operators, brazers, or brazing operators employed for this project are qualified for all welding and brazing procedures, proposed as part of this Project, in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel.". Qualification by previous employer or technically competent group or agency (subject to approval) may be acceptable if following information is included:

    a. Documentation that the previous qualification was for essentially the same procedures proposed and was in full accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel.".

    b. Copy of performance qualification testing record showing who qualified the worker, date of qualification, and work history record showing continuous performance to maintain qualification.

4. Weld and Braze Qualification Records: Maintain and sign certified records of approved procedures used and approved qualified workers employed for welded and brazed joints performed as a part of Prime Contract. Ensure all welding and brazing work can be traced to a specific procedure and welder.

5. Inspection and Examination by Owner, Remedy by Contractor: Owner reserves right to examine, inspect, and test all piping using visual, radiographic, or other recognized testing methods to determine compliance with specified quality control requirements and requirements of applicable regulatory agencies.

    a. Cost of Owner's testing of acceptable installation provided at Owner's expense.
    b. Repair piping installations not passing Owner's quality inspection testing using approved method or replace at no additional cost.
    c. Cost of initial testing of piping not conforming to specified requirements and any retesting of repairs or replacement work shall be deducted from Contract Sum.

E. 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.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Ship materials in manufacturer's containers, fully identified with manufacture's name, trade name, type, class, style, model, grade, size and color.

B. Storage and Protection

1. Store materials, equipment, fixtures, pipe, fittings, attachments, under cover, off ground in original containers as applicable, and protect from physical and weather damage while in storage and during construction.

2. Furnish extra materials identified in technical sections, in original manufacturer's containers and packaging, to Owner at location identified during Preconstruction Conference. Obtain receipt from Owner upon delivery of extra materials and send copy of receipt to Architect.

3. Replace or repair damaged, rusted, corroded or otherwise unusable materials physically damaged or weather damaged equipment as determined by Architect, at no change in Contract Sum.

## 1.9 PROJECT/SITE CONDITIONS

A. Field Measurements

1. DO NOT SCALE DRAWINGS: Refer to Architectural and Structural drawings for dimensions and details, and verify measurements in field before proceeding.

2. Install all items with proper provision for removal and access to coil bundles, valves, and similar components.

3. Layout of equipment, piping, and similar components in Drawings is diagrammatic. Review Drawings in the field, identify interference with other construction and verify dimensions at Site prior to beginning installation.

   a. Obtain exact size and location of all items and openings and confirm all existing conditions in field. Review Shop Drawings of all Contracts.

   b. Coordinate all Heating Work that interferes with other construction with other responsible Contractor.

   c. Obtain exact location and roughing requirements for all equipment furnished by others, but installed by this Contractor before roughing. Owner reserves right to make reasonable changes prior to "roughing-in" without increase in Contract Sum.

4. Report any conflicts to Architect in writing before beginning installation.

## 1.10 SEQUENCING AND SCHEDULING

A. Perform all Heating Work in cooperation with Owner, Architect, Construction Manager, and all Contractors on this Project, and other separate Contractors at the Site.

1. Coordinate all Heating Work with construction schedule requirements in Division 01
2. Coordinate all submittals with the construction schedule and with requirements and schedules contained in Section 01 33 00 – Submittals Procedures.
3. Immediately report any delays in receipt of materials required for Heating Work including circumstances causing delays.

B. Existing Construction: Provide openings, chases, recesses, lintels and bucks required for admission of Heating Work, unless otherwise noted. Do not cut waterproofed floors or walls for admission of equipment or materials without written permission. Do not pierce structural members without written permission.

C. Supports for Heating Work: Provide anchor bolts required supporting or securing Heating Work. Locate settings and check locations as construction progresses. Provide templates or holding fixtures as required to maintain proper accuracy.

D. Cutting and Patching: Bear expense of cutting, patching, repairing or replacing of work of all Contracts required due to fault, error or damage by contractor responsible for Heating Work, unless otherwise specified in Contract Documents. Employ and pay Prime Contractor involved, or if there is no associated Prime Contractor, employ and pay qualified subcontractor as required for corrective work.

E. Refer to Division 01 for cooperation between Contractors. Prior to start of construction:

1. Obtain from Contract Drawings or Architect, exact location of items and openings in construction. Conform to existing conditions in field.

2. Review Shop Drawings of all Contracts.

3. If conflict occurs between Contract Drawings, advise Architect in writing before beginning installation and comply with Architect's directions.

4. Obtain exact location and roughing requirements for equipment furnished by other Contractor or by Owner, but installed by Contractor responsible for Heating Work before beginning roughing.

## 1.11 COORDINATION

A. Pre-Installation Conference:

1. Attend pre-installation conference. Arrange for all subcontractors to be in attendance.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

C. Coordinate Heating Work with plumbing systems, lighting fixtures, ceiling mounted devices, ceiling heights, materials, structural work, maintenance clearances, electric code clearance, and building systems. Verify that Work of all Contractors can be installed without interference with Heating Work.

D. Notify Architect in case of unresolved interferences prior to installation of Heating Work.

E. Adjust exact size, location and offsets of exposed HVAC components to achieve reasonable appearance objectives without increase in Contract Sum.

F. Testing and Balancing: Cooperate with contractor responsible for Testing and Balancing work as required ensuring complete and proper testing, balancing and adjustment of air and water systems. Refer to Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC, for details.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Basis-of-Design Equipment – Provide as specified and scheduled with all options as required for full compliance.

B. Specified Equivalents - If Specified Equivalents (refer to "Definitions" in Part 1 above) are proposed, comply with following requirements:

1. Submit "Specified Equivalent Drawings" as specified in "Submittals" in Part 1 above.

    a. Provide required changes in design and adjacent construction or equipment at no increase in Contract Sum.

        1) Where required, provide larger motors, equipment, additional control devices, valves, fittings, and other miscellaneous equipment necessary for proper operation and provide proper location of roughing and connections to other Contractors.

        2) Provide additional motors, starters, power, wiring, and control wiring required.

        3) Provide revisions to equipment, wiring, support structure, controls, valves, fittings, and other miscellaneous equipment.

        4) Additional Architectural and Engineering work, coordination, and documentation.

    b. If proposed arrangement for Specified Equivalent is rejected, revise to be compliant and resubmit or submit Basis-of-Design Equipment.

2. Submit "Specified Equivalent Product Data" as specified in "Submittals" in Part 1 above to demonstrate that proposed Specified Equivalent is equal to or better than Basis-of-Design Equipment with respect to all performance characteristics, including but not limited to durability, individual equipment operating costs, entire interrelated system operating costs, service access, noise levels, vibration levels, compatibility with Owner's other existing equipment to minimize parts inventory, aesthetics where applicable, and similar characteristics.

3. Do not assume that approval of a specified equivalent submittal implies approval of the installed product. Correct all deviations uncovered during construction and warrantee period that result in or are caused by any lower performance characteristic than the specified Basis of Design equipment.

C. Proposed Equivalents and Substitutions: In addition to requirements described elsewhere in these Contract Documents, all proposed equivalent and substitution products being considered shall be subject to the Specified Equivalent requirements listed above.

## 2.2 MATERIALS

A. Minimum Material Requirements:

1. Construct potable water systems and equipment according to Plumbing Code of New York State.

2. Provide electrical equipment and systems meeting UL standards and requirements of NEC.

3. Provide UL label on all equipment and material with listing service.

4. Material Flammability:

   a. Flame spread rating of 25 or less.
   b. Smoke developed rating of 50 or less.

5. Equipment Verification: Carefully check manufacturer's drawings and specifications as they affect their particular equipment; follow factory instructions for roughing, installation, connection, filling, lubrication, testing, balancing, adjusting, alignment, wiring, and start-up operation.

## 2.3 MOTOR POWER TRAIN ACCESSORIES

A. For all new motor installations, whether in new equipment or installed as replacement motors, provide accessories listed below as required for a complete new drive system.

B. Independently Mounted Direct Driven Load Motor Couplings: Interlocking machined and balanced steel spider locked Molded rubber insert and capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. Include EPDM coupling sleeve for variable-speed applications.

## 2.4 SEALANTS

A. Comply with requirements for sealants in non-fire rated penetrations specified in Section 07 92 00 "Joint Sealants", and also with requirements for Air duct sealants in Section 23 31 00 – Ductwork.

B. Provide premium products specified for each application as appropriate.

## 2.5 PENETRATION FIRESTOPPING

A. Comply with requirements for sealants in fire rated penetrations specified in Section 07 84 13 - Penetration Firestopping.

B. Submit Manufacturers Product Data Sheets for each type of product selected. Certify that Firestop Material is free of asbestos and lead paint, and complies with local regulations.

1. Certification by firestopping manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs) and are nontoxic to building occupants.

C. Submit system design listings, including illustrations from qualified testing and inspection agency that is applicable to each firestop configuration.

D. Submit a project specific Penetration Firestopping Schedule indicating where each firestop configuration will be used.

## 2.6 PAINT AND FINISHES

A. Refer to Division 09 for paint and finish product specifications.

# PART 3 - EXECUTION

## 3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Execution" and Division 02 Section "Selective Demolition" 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 at point of continued use or as otherwise specifically indicated.

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 cap remaining ducts with same or compatible ductwork material.

4. Ducts to Be Abandoned in Place: Cap all duct ends with same or compatible ductwork material.

5. Equipment to Be Removed: Disconnect and remove equipment and all associated accessories. Plug, cap, seal, and otherwise patch to match as required.

6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, protect, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational. Document any existing damage before removals.

7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. Disposition of Removed Components:

1. All material and equipment shown on the drawings to be removed during project Work that is not indicated on the drawings as being either reused or turned over to the Owner becomes the Contractor's property as a part of the project including salvage value and legal disposal cost complete.

2. For components that become the Contractor's property through this removal process: Confirm transfer of ownership in writing then promptly remove from the site and legally process.

3. For components indicated on the drawings to be reused: carefully remove, protect, and store until appropriate time for re-installation. Document any pre-existing damage prior to removals.

4. For pipe and tubing indicated to be reused, reuse only those portions of pipe, tubing, and associated fitting assemblies where they are direct replacements of the as specified and as shown new piping assemblies. Valves, strainers, other piping specialties, and insulation shall not be re-used unless specifically indicated on drawings.

## 3.2 EXISTING CONDITIONS

A. Reuse materials and equipment only as indicated on Drawings. Furnish new equipment and materials in conformance with Contract Documents for all Heating Work, including any material, operation, method or device mentioned, listed or noted within Division 23 Sections, unless reuse is specifically indicated, or unless specified as furnished or installed by Owner, all Contractors, or others.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is otherwise made unserviceable by adjacent or associated work or error, remove damaged or unserviceable portions and replace with new products of equal capacity and quality. Verify, document, and confirm pre-existing damage with Owner and Architect before beginning work.

## 3.3 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are 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.

E. Ensure each equipment manufacturer:

1. Carefully checks Contract Drawings and Specifications applicable to manufacturer's equipment before roughing.

2. Reports to Architect, before or when Shop Drawings are submitted, any discrepancies or conditions applied to manufacturer's equipment that prevents proper functioning, servicing, and other aspects of equipment operation.

3. Provides manufacturer's printed installation instructions for each piece of equipment.

4. Thoroughly instructs Contractor exactly how equipment should be installed, connected, lubricated, started, operated, and similar aspects to ensure all factory instructions are rigidly followed during installation of equipment.

F. Install, test, start, and operate equipment as instructed by manufacturer.

G. Submit written evidence from equipment manufacturer that manufacturer's equipment and systems have been:

1. Installed in strict accordance with manufacturer's recommendations.
2. Properly aligned and adjusted, tested, lubricated, wired, balanced, and similar operations

H. Equipment Connections

1. Provide isolation valves and flanges or unions on the supply and return piping connections to all equipment arranged as required for reasonable service isolation and access.

2. Provide equipment waste, drip, overflow, condensate, and drain connections extended to floor or roof drains or other approved points of discharge.

3. Connect equipment complete and ready-to-use, including all valves, piping, piping accessories, gauges, relief valves, vents, drains, insulation, sheet metal work, controls, dampers, and similar components required.

I. Precautions Against Freezing: In addition to applicable requirements in Division 01 and individual technical sections, take all necessary precautions with equipment and systems to prevent damage to building, piping, equipment, and other components due to freezing and water leakage until final acceptance. Before freezing weather occurs, make certain all:

1. Safety features are properly functioning.
2. Freeze protection is tested and sensing elements are properly located.
3. Openings around outside grilles, louvers, and similar items are properly sealed; notify Architect in writing if openings are not adequately sealed.
4. Outside air dampers are tight fitting and operational, and damper motors are properly winterized.
5. Air systems are properly balanced.
6. Proper insulation is installed where required.

J. Concealment: Conceal all Work not specifically shown on the Drawings as exposed. Note piping risers may be shown outside of walls due to scale of drawing symbols – the general intent is for these pipes to be concealed within the general construction if possible or if not possible, to be within riser chases. If for any reason concealment is impossible, notify the Architect and obtain written approval before starting that part of the Work.

K. Exposed Items: Install exposed items as shown on Drawings or as approved by Architect. Obtain Architect's approval for final arrangement and appearance before installing items in areas without ceilings.

L. Damaged Components and Replacement: If pipe, duct, insulation, or any HVAC component or equipment is damaged in appearance or is otherwise unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

## 3.4 ERECTION OF SUPPORTS AND ANCHORAGES

A. Provide a complete system of support and anchorage for all Contract work.

B. Refer to Section 23 05 29 - Hangers and Supports for HVAC Components, Section 23 05 43 – Mechanical Vibration and Movement Control, and Division 05 and Division 06 complete for detailed additional requirements.

## 3.5 MECHANICAL PENETRATIONS, WATERPROOFING, AND SEALING

A. Openings Through Roofs: Curbs are required for rooftop air handling equipment, ventilators, fans, piping penetrations, etc. Roofing, flashing, and general waterproofing are the responsibility of the Contractor unless specifically indicated otherwise elsewhere in the Contract Documents. Refer to Architectural Drawings for related work by others.

1. Use factory pre-fabricated units as specified and noted on Drawings.

2. Caulk and waterproof neatly with additional material as required.

3. Employ the services of an approved roofing sub-contractor for all patching and/or new work indicated as part of the Heating Work.

4. Any roofing work performed under this Contract shall be performed in such a way as to not void any existing roofing warrantee. Additionally, whether there is a roofing warrantee currently in force or not for roof in area of new penetrations, all new penetration work shall be warranted leak free for a period not less than one year from final acceptance of project.

5. Provide structural support for roof deck around all roof curbs and roof deck penetrations larger than 12 inch x 12 inch, unless specifically indicated otherwise elsewhere on the Contract Documents.

B. Opening Through Outside Walls:

1. Guarantee all penetrations to be thoroughly air and watertight. Caulk and flash duct penetrations in accordance with specifications, details on Drawings, and as required.

2. Install louvers in accordance with specifications, manufacturer's recommendations, and details, as required to achieve guaranteed air and watertight penetrations. Direct drainage to drip away from building surface.

3. Use special waterproof construction as directed.

4. Provide mechanical sleeve seals for piping penetrations.

5. Provide structural support for wall above all penetrations wider than 12 inches, unless otherwise indicated elsewhere on the Contract Documents.

C. Openings Through Floors and Inside Walls: Provide through penetration systems for all mechanical work floor and wall penetrations which do not compromise the integrity of the floor or wall with regards to fire rating, smoke passage rating, acoustical noise reduction rating, or seismic rating. Insure through penetration system does not transmit mechanical vibrations to building walls or floors. Seal all floor penetrations to effectively block the passage of smoke and fumes.

1. Provide structural support for floor deck around all penetrations larger than 12 inches in any dimension, unless specifically indicated otherwise elsewhere on the contract documents.

## 3.6 FIRESTOPPING

A. Provide Through-Penetration Firestopping Systems and Devices listed in UL Fire Resistance Directory under categories XHCR and XHEZ and conforming to construction type, penetrant type, annular space requirements and fire rating indicated or required for each application.

B. Provide systems that withstand passage of cold smoke either as inherent property of system or by use of separate product included as part of UL system or device designed to perform this function.

C. Applied Fireproofing:

1. Coordinate the installation of hangers, supports and accessories from the structural steel with the Contractor responsible for fireproofing. Install all hangers and supports prior to fireproofing.

2. Repair and/or replacement of any fireproofing removed or damaged as a consequence of the installation work of the Heating Work Contract shall be the responsibility of the Heating Work Contractor.

a. Employ the services of an approved fireproofing contractor to repair or replace the fireproofing by patching any areas that have been removed or damaged due to the installation of work after the completion of the fireproofing.

b. Repaired or replacement fireproofing shall match the fireproofing adjacent to the repaired area. All warranties shall be maintained.

c. Remove all excess applied fireproofing from surfaces adjacent to those requiring it, leaving area clean and neat.

## 3.7 PAINTING

A. Painting of HVAC systems, equipment, and components is additionally specified in Division 09 Sections on Painting.

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

C. Vary initial and final coat colors slightly as required to provide positive identification between coats. Do not proceed with final coat until initial coat is properly cured per manufacturer's instructions, and has been approved as complete by Owner's Project Representative. Final coat shall completely conceal initial coat(s).

D. Paint Requirements:

1. Provide painted finish for HVAC components (exposed equipment, piping, duct, supports and insulation in particular) exposed to view in finished spaces such as gymnasiums, classrooms, offices, corridors, etc. Provide factory painted finishes as specified elsewhere or if not factory painted then field painted. Refer to Division 09 for painting specifications and additional painting requirements if required.

    a. Provide touch up painting as required to repair, or replace as directed, damaged factory finishes of HVAC components.

2. Paint all exposed metal surfaces that will be above 150 degrees F when in operation, with two coats of heat resistant paint.

3. Paint all miscellaneous fabricated ferrous supports complete.

4. Paint all ferrous piping and components located outdoors as specified in Division 09, except where insulation is to be applied over piping or component.

5. For piping that will be subject to moisture induced corrosion on the exterior of the piping, provide one full coverage coat of corrosion inhibiter equal to "Polyguard RG-2400" on the following ferrous (steel) piping and fittings before insulation is applied:

    a. All exterior ferrous piping.
    b. All ferrous piping where the fluid in the piping operates at below ambient conditions (all cooling piping)
    c. All below grade ferrous piping.

6. Do not paint

    a. Chrome plated materials, aluminum and brass valves, or brass trim on iron body valves, stainless steel materials, copper indirect waste piping, laboratory waste and vent piping.

    b. Piping above finished ceiling spaces, except un-insulated ferrous piping and supports.

c. Exposed copper pipe, brass valves, or brass trim on iron body valves, or machinery or equipment with factory-applied finish, unless otherwise specified.

7. Coating Systems: Comply with application and material requirements specified in Division 09.

E. Maintain systems during construction, temporary use, and until acceptance by Owner.

1. Properly lubricate all HVAC systems bearings during use.
2. Maintain limit controls, overload devices, and safety controls in operating condition during use

## 3.8 ALTERATIONS

A. Provide protection of existing facilities, demolition and removals, replacement and restoration, including patch-to-match requirements, and hazardous materials procedures to install Heating Work in conformance with Division 01 requirements.

B. Provide cutting and patching required to install Heating Work in accordance with the requirements of Division 01 covering cutting and patching.

## 3.9 ADJUSTING AND CLEANING

A. Adjust all work as required to insure systems perform as designed and as intended, including but not limited to the following:

1. Adjust all registers and diffusers to insure even air distribution free of objectionable drafts. Include all new and all existing to remain registers and diffusers on systems where HVAC modifications are made.

2. Adjust all hangers and supports to insure proper piping slope, alignment of flexible connections, even loadings, proper venting and draining, proper control over thermal expansion, etc.

3. Adjust all mechanical equipment insuring it runs properly as intended, providing the performance specified and required, and as required to maintain all warrantees.

B. Clean work furnished or provided as part of Heating Work, including but not limited to equipment, control panels and devices.

1. Refer to and comply with Section 01 50 00 - Temporary Facilities and Controls for additional requirements for cleaning during construction and Section 01 77 00 – Closeout Procedures for additional requirements for final cleaning.

2. Remove debris, leftover piping, tubing, metal, insulation, cartons, papers, etc., resulting from Heating Work.

3. Remove all rust, dirt, oil, etc. from Heating Work to be painted and maintain in condition ready for painting.

4. Clean inside and outside of all equipment and distribution systems provided including (but not limited to) following:

   a. All enclosures.

   b. Remove all rust, oils, and similar contamination from all equipment, piping and supports to be painted, and leave components ready for painting.

   c. Remove debris, leftover piping, wiring, tubing, metal, insulation, cartons, papers, and similar items left in building or on Site. Clean building as often as necessary and when directed by Architect.

C. Final Cleaning: In addition to requirements specified in Section 01 77 00 – Closeout Procedures and other sections in Division 23, provide following measures.

1. Where heating units have been used to provide temporary heat, clean all permanent filters, replace all disposable filters, and clean all ducts, blowers, and coils.
2. Clean all piping strainers and replace all "startup" screens with permanent screens.
3. Provide written notification to Architect upon completion of all final cleaning procedures and request inspection of final cleaning.

## 3.10 DEMONSTRATION OF COMPLETED SYSTEMS:

A. Prior to Final Completion, thoroughly demonstrate and instruct Owner's designated representatives in care and operation of all heating and ventilating systems and equipment provided in Heating Work. Provide necessary skilled labor to operate all systems for not less than 5 days and provide required instruction.

1. In addition to Contractor's instruction, arrange for technically qualified factory representatives to train Owner's designated representatives in care, maintenance, and operation of following manufacturer's equipment and systems.

   a. Temperature controls.
   b. Central station air handling equipment and units.
   c. Energy recovery equipment.

2. Coordinate and schedule time and place of all training through Architect at Owner's convenience.

3. Submit letters verifying satisfactory completion of all instruction including date of instruction, names of persons in attendance and countersigned by authorized representative of Owner.

4. Until final acceptance, Contractor retains full responsibility for systems operations and maintenance, even though operated by Owner's personnel during instruction, unless otherwise agreed to in writing.

5. During instruction, provide list, sealed in clear plastic, outlining operating, maintenance, and starting precautions and procedures to be followed by Owner for operating systems and equipment.

B. Valve Identification Chart: Provide a valve chart for all valves installed in contract.

1. Provide 8-1/2 inch x 11 inch minimum size Valve Identification Chart, typed in capital letters, mounted under clear laminated plastic; secure to wall where directed.

2. Valve Numbering System: Extension of and compatible with existing valve numbering system, where valves are installed in existing building or in addition to existing building. Do not duplicate existing numbers; verify existing numbers in the field.

3. List all valves included in Contract. Obtain necessary information containing the following:

   a. Valve number, piping system, system abbreviation (as shown on valve tag) and location of valve.
   b. Normal operating position (open, closed, or modulating).
   c. Clearly identify special purpose valves (for emergency shutoff, etc.).

C. Lubrication Chart: Provide minimum 8-1/2 inch x 11 inch lubrication chart for all Work in Heating Work Contract, typed in capital letters, mounted under clear laminated plastic, and secured to wall where directed by Architect.

1. List all motors and equipment including following information:

   a. Name and location of equipment.
   b. Type of lubrication recommended by manufacturer.
   c. Lubrication period recommended by manufacturer.

2. Lubricate all motors immediately after installation and perform lubrication maintenance until final acceptance by Owner.

D. Air Filter Chart: Provide an air filter chart for all equipment installed in contract.

1. Chart shall be 8-1/2 inch x 11 inch minimum size, typed in capital letters, mounted under clear laminated plastic; secure to wall where directed.

2. List all equipment that includes filters in Contract. Obtain necessary information containing the following:

   a. Name and location of equipment
   b. Type of filters recommended by the manufacturer.
   c. Size of filters for each piece of equipment.
   d. Recommended replacement schedule from unit manufacturer.

END OF SECTION 23 05 00

# SECTION 23 05 13 - COMMON ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes:

1. 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.

2. Starters and drive train accessories for electric motors.

   a. Refer also to Section 23 29 00 for Variable Frequency Motor Controllers.

3. Electrical auxiliary components required for HVAC systems that are not specifically identified in “E” series Drawings or Division 26.

4. Electrical wiring required for HVAC systems that is not specifically identified in “E” series Drawings or Division 26.

### 1.3 SUBMITTALS

A. General: Submit all action submittals required by this Section concurrently.

B. Action Submittals:

1. Product Data: For each type of product indicated, demonstrating compliance with all specified performance and construction characteristics.

C. Closeout Submittals:

1. Installation, Operation, and Maintenance Data: For motors, drives, and electrical power components, include in operation and maintenance manuals.

   a. Wiring Diagrams: Employ competent technical aid to prepare composite wiring diagrams for field wiring of power, signal, and control wiring for all equipment and systems installed as part of the HVAC Work. Deliver diagrams to proper parties in time for roughing of conduit and equipment connections. Clearly indicate all items to be mounted or wired as part of DIVISION 26. Include as built wiring diagrams in O&M manual.

## 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. Manufacturers: Provide products by one of following manufacturers or equal, except where unusual configurations involving frame, hermetic seals, shaft, bearing, or starting characteristics are peculiar to particular item of equipment as specified by Architect:

1. National Resource Management (NRM).
2. Baldor.
3. General Electric.
4. U. S. Motors.

B. Provide all motors required for the work of Division 23 specifications. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or individual technical specification sections.

C. Provide all motors suitable for operation at the frequency, voltage, and phasing of the building power.

D. Provide motors 1/2 HP and larger and motors indicated as driven by variable speed drives, designed for operation on 3-phase power, voltage as shown on electrical plans, +/- 10 percent, unless specifically indicated otherwise on drawings.

E. Provide constant speed motors 1/3 HP and smaller designed for operation on single phase, 120 volts +/- 10 percent.

F. Comply with NEMA MG 1 unless otherwise indicated.

G. Comply with IEEE 841 for severe-duty motors.

## 2.2 MOTOR CHARACTERISTICS AND APPLICATIONS

A. Provide each motor suitable for continuous duty operation at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level, and suitable for speed, enclosure, rating, type and horsepower not less than as scheduled or specified in Contract Documents. Provide motor enclosure and maximum allowable temperature rise in degrees Centigrade over 40 deg. C ambient as follows, unless otherwise specified:

1. General Purpose: Drip-proof 40 deg. C or encapsulated design 60 deg. C.
2. Roof-top unit applications: Totally enclosed fan-cooled 50 deg. C or drip-proof encapsulated design 60 deg. C.
3. Motors, wiring, and disconnects installed in potentially flammable atmosphere: UL listed, NEC rated explosion proof construction, fan-cooled 50 deg. C rise.

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.

C. Each equipment manufacturer is responsible for ensuring motors supplied with manufacturer's equipment are fully compatible with the application and capable of starting and running driven equipment without undue noise, heating, or distress.

## 2.3 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.
5. Electronically Commutated Motor (ECM)

B. Motors 1/20 HP and Smaller: Shaded-pole type.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

D. Variable Speed Motors: Electronically commutated motor (ECM) shall be of permanent magnet, brushless DC premium efficiency design with variable speed electronic controller capable of maintaining constant speed, torque, and/or cfm as required by service, capable of accepting 0-10vdc or 4-20mA speed control signal from building management system. Adjustable slow start and gradual speed changes, permanently lubricated ball bearings, and extra quiet operation are all included.

E. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

F. 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.

## 2.4 POLYPHASE MOTORS

A. Single Speed General Application Motors:

1. NEMA MG 1, Design B, medium induction motor.

2. Efficiency: Premium efficiency, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Random-wound, squirrel cage rotor.
5. Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
6. Insulation: Class F.
7. Temperature Rise: One class below insulation rating.
8. Motors 15 HP and Larger: NEMA starting Code F or Code G.
9. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
10. Enclosure Material: Manufacturer's standard rolled steel or cast iron enclosures corresponding to NEMA rating and application requirements.

B. Multi-Speed General Application Motors:

1. Similar to single speed motor requirements above, with separate winding for each speed.

2. 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.

C. Motors Used with Variable Frequency Controllers:

1. Motors shall meet all other requirements of this document, the driven equipment manufacturer, and the Variable Frequency Controller manufacturer, and be rated for this service with the drive and voltage intended. Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

2. All three phase motors for use with variable frequency controllers shall be special application, inverter duty premium efficiency motors of cast iron construction.

3. Ratings shall be in accordance with NEMA MG-1, Part 31 requirements for the specific application.

4. 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.

5. Class B temperature rise; Class F insulation.

6. Thermal protection via one Class F thermostat per phase, NEMA MG 1 compliant with requirements for thermally protected motors.

## 2.5 MOTOR ACCESSORIES

A. For all new motor installations, whether in new equipment or installed as replacement motors, provide accessories listed below as required for a complete new drive system.
B. Direct connected motors: provide with flexible couplings if required by application and OSHA approved belt guards surrounding rotating machinery.

## 2.6 STARTERS

A. Manufacturers: Provide all starting equipment and control devices manufactured by same manufacturer and furnished through single responsible supplier unless otherwise specified in Contract Documents. Factory-wired or assembled packaged equipment may be provided with starting equipment of any acceptable manufacturer. 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. Cutler-Hammer
2. General Electric
3. Square D

B. Provide starters, contactors, and controllers complying with applicable NEMA standards, minimum size 0, and enclosed in enclosures of type appropriate for environment where installed including general purpose, explosion proof, weather resistant, or weather-tight construction as required.

C. Ensure all parts subject to wear, arcing, and similar use are easily removable.

1. Provide necessary auxiliary contacts for each starter subject to electrical interlock or automatic control.

2. Equip magnetic starters for motors operating 208 volts and over, line-to-line, equipped with self-contained light loads imposed thereon with a control transformer having a 120-volt grounded secondary winding, and having 120-volt starter operating coils.

D. Provide combination-type magnetic starters with fused disconnect switches. Fuse with class R fuses. Protect all starters with manual reset, solid state overload relay equal to (Square "D" motor logic) in one leg of single phase line to neutral circuits, in two legs of single phase line-to-line circuits, and in three legs of 3-phase circuits.

E. Provide 6-volt, red pilot light, integral transformer and long life bulb for all starters and contactors.

F. Manual Starters: Toggle operated, single pole for line to neutral circuits, two pole for line-to-line circuits, with thermal overload devices and neon pilot light; flush mounted unless shown otherwise, ganged with selector switch for multispeed applications. Provide manual starters similar to one of the following:

1. General Electric CR-101
2. Cutler-Hammer 9101
3. Square D Class 2510

G. Combination Magnetic Starters: Single speed, across the line, HAND-OFF-AUTO selector switch in cover. Provide combination magnetic starters similar to one of the following:

1. Cutler-Hammer 9589
2. General Electric CR-107
3. Square D Class 8538

H. Magnetic Contactors: With control coil in series with temperature controls as required.

I. Refer to Section 23 29 00 – VARIABLE FREQUENCY MOTOR CONTROLLERS for requirements of these devices.

## 2.7 COMPONENTS

A. Electrical Wiring: Provide all materials conforming to NEMA Standards and UL approved for intended service. Refer to appropriate sections in Division 26.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which materials and methods are to be installed and notify Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in acceptable manner.

1. Installation indicates conditions are acceptable to Contractor as required to ensure requirements for applicable warranty or guarantee can be satisfied.

2. Motors and Starters: Confirm electrical characteristics for all equipment.

3. Electrical Wiring: Check all electrical wiring associated with equipment for compliance with specifications and correctness of connections. Correct wiring in event equipment or devices fail to function in specified manner, whether due to incorrect connections or improper information and wiring diagrams.

B. Inspect and perform tests on project electrical wiring, including infrared scans (thermography), resistance testing, or other industry standard testing as required to demonstrate acceptable wiring. Owner reserves the right to provide their own additional similar testing:

1. Cost of Contractor's testing included in bid price. Cost of Owner's testing of acceptable installations provided at Owner's expense.
2. Repair installations not passing Contractor's or Owner's quality inspection testing using approved method or replace at no additional cost.
3. Cost of initial testing of wiring not conforming to specified requirements and any retesting of repairs or replacement work deducted from Contract Sum.

## 3.2 INSTALLATION

A. Motors and Starters

1. Correct, at no additional cost, any misapplied motor or starter combination and improper thermal overload devices for motor starters provided as part of HVAC systems or components, along with damage to other equipment or construction.

2. Motors: Provide motors furnished by equipment manufacturer, specifically manufactured or selected for equipment served; mounted, and installed to provide complete installation that is substantially noiseless in performance under intended use. Replace motors unsatisfactory to Architect with new motor.

3. Starters and Accessories

   a. Provide starters and disconnects for all HVAC equipment. Refer to Equipment Schedules.

   b. Furnish properly tagged and identified devices specifically indicated on "Electric Equipment and Control Schedule" as supplied by HVAC systems suppliers and determine coordinated location and time for delivery of devices.

   c. Provide auxiliary contacts required for temperature controls, interlock with other equipment, alarms, and similar components and applications.

B. Miscellaneous Electrical Wiring included in HVAC systems installations:

1. Provide all control wiring and power wiring for all equipment and associated control devices (including automatic control system) required for HVAC systems and components.

2. Comply with all applicable NEC requirements. Install all electric wiring in accordance with all local and state codes and regulations having jurisdiction.

3. Wiring for Controls: Provide wiring specified in Section 23 09 00 – Instrumentation and Control for HVAC, for all control devices required for temperature control system and other miscellaneous controls not included in "Electrical Equipment and Control Schedule".

4. Allow sufficient headroom under equipment as directed for each location (unit heater, etc.). Verify space available for each equipment item. Refer to Architect for any correction, discrepancy or suggested change in size of location.

5. Secure all equipment and fixture mountings, wiring devices, and accessories (clips, supports, etc.) to structure with screws, bolts, or similar items; nailing not acceptable.

END OF SECTION 23 05 13

# SECTION 23 05 19 - METERS AND GAUGES FOR HVAC SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Thermowells.
2. Test plugs.
3. Test-plug kits.

### 1.3 SUBMITTALS

A. Procedural Requirements: Comply with requirements of Section 01 33 00 - Submittals and as modified below.

1. Specified Products: If product to be incorporated into Project is specified by name and product designation in Part 2 below, submit "**As-Specified Verification Form**" (attached to Section 01 33 00 - Submittals) in lieu of "Product Data" identified below in this Article.

2. Equivalent Products or Substitutions: If product to be incorporated into Project is not specified by name and product designation in Part 2 below, comply with all Action Submittal requirements specified below.

B. Action Submittals:

1. Submit all action submittals required by this Section concurrently.
2. Product Data: For each type of product indicated, demonstrating compliance with specifications. Include schedules of locations and ranges proposed.

C. Closeout Submittals:

1. Approved submittal.

a. If "**As-Specified Verification Form**" submittal is approved, also include product data for all valves used.

2. Include all information required in Section 01 78 23 – Operation and Maintenance Data for all meters and gauges used. Include wiring diagrams for meter power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 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 or Steel Piping: solid machined de-zincification resistant brass or stainless steel.
4. Type: Stepped shank unless straight or tapered shank is indicated.
5. External Threads: ASME B1.20.1 pipe threads, size as required for sensors.
6. Internal Threads: ASME B1.1 screw threads, size as required for sensors.
7. Bore: Diameter required to match thermometer bulb or stem.
8. Insertion Length: Length required to match thermometer bulb or stem.
9. Lagging Extension: Include on thermowells for insulated piping and tubing.
10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin unless otherwise required by sensor manufacturer.

2.2 TEST PLUGS AND ACCESSORIES

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. 3D instruments Inc.
2. Flow Design, Inc.
3. Peterson Products Co
4. Trerice, H. O. Co.
5. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
6. Weiss Instruments, Inc.

B. Test Plugs:

1. Description: Test-station fitting made for insertion into piping tee fitting.

2. Brass or stainless steel body, NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread with Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber core inserts and gasketed and threaded cap with retainer. Include extended stem on units to be installed in insulated piping.

3. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

C. Test-Plug Kits

1. Furnish one test-plug test kit containing two thermometers, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

2. 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 deg F.

3. 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 deg F.

4. Pressure Gauge: One pressure gauge as specified above with insertion type adapter probe. Dial range shall be 0 to 100 psig.

5. Carrying Case: Metal or plastic, with formed instrument padding.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees. Provide thermometer stems of length to match thermowell insertion length.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes. For pipe sizes 1 inch and smaller, increase pipe size by one size at location of thermowell to minimize obstruction.

C. Install thermowells with extension on insulated piping. Insulate fitting past piping well and neatly terminate insulation at thermometer body minimizing heat loss while allowing for adjustment.

D. Fill thermowells with heat-transfer medium.

E. Install test plugs in piping tees in location that allows for ease of insertion of standard test kit probes.

3.3 LOCATIONS

A. Test Plugs and Test Plug Kits:

1. Provide Pressure / Temperature Test Plugs at the supply and return connections to each new air / water heat transfer coil, adjacent to each thermometer and pressure gauge, and as noted on the drawings.

2. Furnish one Test Plug Kit loose to Owner, and provide for training of Owner's personnel in its use.

END OF SECTION 23 05 19

# SECTION 23 05 23 – GENERAL DUTY VALVES FOR HVAC PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Brass and bronze ball valves.
2. Iron, single-flange butterfly valves.
3. Manual Balancing valves
4. Automatic Flow Control Balancing valves.
5. Air vent valves

### 1.3 DEFINITIONS

A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene copolymer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

### 1.4 SUBMITTALS

A. Procedural Requirements: Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.

1. Specified Products: If product to be incorporated into Project is specified by name and product designation in Part 2 below, submit "**As-Specified Verification Form**" (attached to SECTION 01 33 00 - Submittals) in lieu of "Product Data" identified below in this Article.

2. Equivalent Products or Substitutions: If product to be incorporated into Project is <u>not</u> specified by name and product designation in Part 2 below, comply with all Action Submittal requirements specified below.

B. Action Submittals:

1. Product Data: Submit concurrently for each type of valve proposed, demonstrating compliance with requirements.

C. Closeout Information, for inclusion in Operations and Maintenance Manual:

1. Approved submittal.

a. If "**As-Specified Verification Form**" submittal is approved, also include product data for all valves used.

2. Include all information required in SECTION 01 78 23 – Operation and Maintenance Data.

3. Receipt: For spare automatic flow control valve cartridges and Differential Pressure Flow Test Kit(s).

4. Valve Chart: Refer to Section 23 05 00 – Common Work Results for HVAC, for details.

## 1.5 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 B31.9 for building services piping valves.

## 1.6 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 ball valves open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.

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.

## 1.7 EXTRA MATERIALS

A. Furnish extra materials that match products specified and that are packaged with protective covering for storage and identified with labels describing contents. Include receipt signed by Owner's representative in closeout documentation.

1. Provide additional Automatic Flow Control Valve cartridges as specified below.
2. Provide one complete Differential Pressure Flow Test Kit for each different type of balancing or flow control valve included in the project, with training as described below.

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. Handlever: For quarter-turn valves NPS 5 and smaller.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. 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.

2. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1.
2. Grooved: With grooves according to AWWA C606.
3. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE AND BRASS BALL VALVES

A. Two-Piece 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. Milwaukee Valve Company.
c. NIBCO INC.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Solder or Threaded.
g. Seats: PTFE or TFE.

h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full or Regular per application schedule.

## 2.3 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. Conbraco Industries, Inc.; Apollo Valves.
b. Milwaukee Valve Company.
c. NIBCO 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 A 216 carbon steel, ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM/Teflon, reinforced, resilient, for water temperatures up to 250 deg. F at 150 PSI.
f. Stem: 316 or 416 stainless steel shaft mounted within corrosion resistant bearings.
g. Disc: Aluminum bronze, bronze, or nickel coated iron.

## 2.4 MANUAL BALANCING VALVES

A. Provide combination globe-type calibrated flow measuring balance, shutoff, and throttling valve with provision for attaching portable differential pressure meter with each meter connection having positive shutoff access valves equipped with removable insulating cover providing minimum R of 4.5. Rated for 250 PSI at 250 deg. F and provided with calibrated nameplate, 1/4-inch drain/purge port, and drip-tight shut off. Similar to “CBV” by Armstrong, “3D” by B & G, or similar products by Tour & Anderson.

B. Threaded, grooved, or flanged ends as required to fit system piping with bronze, A-metal, or dezincification resistant brass body for pipe sizes 1/2-inch to 2-inches inclusive or cast or ductile iron body with bronze internal parts and Teflon or EPT seals rated for the service fluid and temperature for pipe size 2-1/2-inches and larger.

1. Valves designed to allow for presetting of balance points for proportional system balance prior to system start up.

C. Valve Size: As required to meet the Cv indicated on the Drawings, or if not indicated on Drawings, provide the larger of pipeline size or size required to provide maximum 5 ft. water gauge pressure drop at design flow.

D. Read-Out Ports: Include internal EPT inserts and check valves.

E. Adjustment Knob: Includes minimum of four full turns (1440 degrees) from bubble tight shutoff to full open position and includes pre-set feature indicating degree of valve opening including memory position stop and indicator.

## 2.5 AUTOMATIC BALANCING VALVES

A. Provide each valve with an identification tag attached by chain, factory marked with the zone identification, valve number and flow rate. Valve to be line size.

B. The GPM for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within 5 percent of the specified GPM over at least 95 percent of the control range. Select and submit on automatic flow control valves based on flowrates shown on approved submittals.

C. For 1/2 inch – 2 inch, the flow cartridge shall be removable from the Y- body housing without the use of special tools to provide access for regulator change-out, inspection and cleaning without breaking the main piping.

D. Pump head requirement: The permanent pressure loss added to the pump head shall not exceed seven feet.

E. Each valve shall have two P/T test plugs.

F. Construction:

1. For 1/2” through 2” pipe sizes: Assembly consisting of a de-zincification resistant (DZR) brass, bronze, or A-metal Y-type body, integral full port SS ball and stem ball valve and ‘O’ ring type union. For all insulated pipe services, provide manufacturer’s pre-formed insulation cover to fit each valve, with extended, insulated, non-condensing handle on ball valves.

2. Stainless steel internal flow cartridge body and wear surfaces, with machined threads for spring free height adjustment, permanently marked with the GPM and spring range.

3. Factory leak tested at 100 psi. air under water.

G. Flow Verification:

1. Differential pressure measured across the valve shall be measured for flow verification and to determine the amount of system over heading or under pumping.

H. Design Make: IMI Flow Design Inc.

## 2.6 AIR VENTS

A. Manual Air Vents:

1. For All Pipe Sizes In Accessible Locations Only: Bronze body, quarter turn ball valve with minimum 1/4-inch discharge and inlet connections. Provide collection chamber at inlet and 1/4-inch tube with return bend on outlet, piped to point of collection.

2. For Terminal Units In Accessible Locations: Bronze or brass body and non-ferrous internal parts, 150 PSIG working pressure, 225 deg. F operating temperature. 1/8-inch MNPT inlet connection. Coin or key operated, supply three keys minimum to owner. Similar to "Model 4V" by Bell & Gossett.

# 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. Verify dielectric bolt kits are provided for flanged connections between dis-similar materials.

E. Do not attempt to repair defective valves; replace with new valves.

## 3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Install isolation valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

1. Install boiler isolation valves on system side of boiler specialty components especially safety components like relief valves and low water cutoff devices.

B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 inch and Smaller: Threaded or solder joint ends.
2. For Copper Tubing, NPS 2-1/2 inch and larger: Flanged ends.
3. For Steel Piping, NPS 2-1/2 inch and Larger: Flanged or grooved ends.

## 3.3 GENERAL DUTY VALVE SCHEDULE

A. Unless otherwise specifically indicated elsewhere, use the following:

B. Hydronic Flow Shutoff Service:

1. 2 inch and smaller: Full Port Ball Valves
2. 2-1/2" and larger: Butterfly Valves.

C. Flow Adjustment and Balancing:

1. Provide line size manual adjustment balancing valves for service on branch main lines serving multiple terminal loads, where shown on drawings.

2. Provide line size automatic flow control balancing valves for all individual terminal loads. Size valve flow cartridges based on approved equipment submittal flow rates where different from that scheduled. Include in contract changing cartridges on 10% of automatic flow control valves to some different flow as required during TAB and system commissioning work. Turn over original cartridges which have been changed, or the unused portion of the 10% extra, to the Owner with receipt.

3. Select final flow based on approved submittals, not on flow indicated on contract documents.

4. Train Owner's representative on balancing / flow control valve adjustment, use of differential pressure flow test kit, and also on changing automatic flow control valve cartridges.

D. Hydronic System Drain Service: Provide drain valves at all system local or global low points as required for complete system drainage.

1. 2-1/2 inch and larger service: Provide ¾ inch full port ball valves with ¾ inch hose thread end and chained cap.
2. 2 inch and smaller service: Provide ¾ inch full port ball or globe valves, with ¾ inch hose thread end and chained cap.

E. Hydronic System Air Venting:

1. Manual vents: provide standard or full port ball valve, minimum 1/4" NPT; ½" NPT on 4" and larger piping.

2. Provide Standard Capacity Type Automatic Air Vent at accessible points in piping system where air may collect, including all local high points and at the end of each horizontal run before a drop in elevation.

a. If any such point will be inaccessible after construction is complete, provide only Manual Air Vent in lieu of automatic, installed as described below.

## 3.4 VALVE INSTALLATION

A. Locate valves for easy access and provide separate support where necessary.

B. Install valves in horizontal piping with stem at or above center of pipe.

C. Install valves in position to allow full stem and handle movement.

D. Install all Manual Air Vents with air collection chamber above flow piping (minimum line size diameter x 6 inches long), and minimum ¼" tube extended to accessible location, terminating with ball valve located so liquid discharged during venting may easily be collected in minimum 1 quart container.

1. Coin vents may be connected directly to equipment served.

## 3.5 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.

END OF SECTION 23 05 23

# SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC COMPONENTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes

1. Hangers and supports for (but not limited to) following components:

   a. Piping hangers and supports
   b. Duct hangers and supports
   c. Equipment hangers and supports

2. Roof mounted supports and equipment penetrations including (but not limited to):

   a. Roof curbs.
   b. Pipe and duct supports.
   c. Combination equipment / pipe penetration curbs

3. Miscellaneous components and accessories including (but not limited to):
   a. Fasteners
   b. Insulation protection systems

### 1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

### 1.4 PERFORMANCE REQUIREMENTS

A. This section does not detail mechanical vibration, movement, wind load, or seismic control requirements. Refer to Section 23 05 43 – MECHANICAL VIBRATION AND MOVEMENT CONTROL for additional hanger and support requirements.

B. Provide corrosion resistant construction as described below for hangers, hanger rods, supports, fittings, hardware, etc, unless otherwise noted or approved. Note that not all products described below are available in corrosion resistance as required for all applications listed – select appropriate corrosion resistant products as required. Multiple conditions may apply, in which case the more corrosion resistant construction is required:

1. General purpose indoor: ASTM B-633 Fe/Zn 25 minimum zinc plated fasteners, ASTM B-653 G90 minimum sheet steel, factory baked enamel paint, or anodized.
2. In contact with copper: Copper plated for size identification and felt lined or plastic coated.
3. In contact with aluminum: Same aluminum alloy as equipment or 300 series stainless steel. 300 series stainless steel fasteners.
4. Outdoors: 300 series stainless steel or post-fabrication (after forming, welding, drilling, etc.) ASTM A-153 hot dipped galvanized steel, minimum coating thickness 3 mils.

C. Allowable Working Loads:

1. Use only manufacturer's load rated hangers, supports, and fasteners designed and rated for the intended service.

2. Do not load connectors, hangers, or supports to more than the manufacturers′ recommended working load or the following:

   a. Use a safety factor of 5:1 minimum with respect to manufacturers′ published ultimate shear strength.
   b. Use a safety factor of 10:1 minimum with respect to manufacturers′ published ultimate tension or pull-out strength.

D. 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, service loads, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

## 1.5 SUBMITTALS

A. Product Data: Submit manufacturer's product literature, technical specifications, and other data required to demonstrate compliance with specified requirements for following components:

1. Hangers and supports
2. Roof mounted supports
3. Miscellaneous components

B. Roofing Work:

1. Submit qualifications of proposed roofing and structural subcontractor(s)

2. Submit copy of any existing roofing warranty and certification by existing warranty holder that proposed roofing subcontractor is certified to provide compliant roofing warranty work and that this project's roofing work will not (before construction) and has not (after construction) voided any warranty.

3. Submit copy of new warranty for roofing performed on existing out-of-warranty roofing.

C. Shop Drawings: Submit intended custom support construction for approval.

D. All supports, etc., shall meet the approval of the Architects / Engineers. Submit shop drawings showing fabrication and installation details including calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Include detailed layout and loading drawings for all above roof piping and equipment.

## 1.6 QUALITY ASSURANCE

A. Comply with applicable requirements of following standards for all hangers and supports:

1. MSS-SP-58 Pipe Hangers and Supports – Materials, Design, and Manufacture.
2. MSS-SP-69 Pipe Hangers and Supports – Selection and Application.
3. ANSI / ASME Code for Pressure Piping B 31.1
4. ASTM standards for corrosion resistant Zinc coatings.
5. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
6. UL 203 Standard for Pipe Hanger Equipment and Fire Protection Service
7. Metal Framing Association MFMA-2
8. ANSI/ NFoPA NDS - National Design Specification for Wood Construction
9. SMACNA – Sheet Metal and Air Conditioning Contractor's National Association, Inc.

B. All welding shall be approved procedures performed by approved welders. Refer to Division 05 Section for "STRUCTURAL STEEL FRAMING", and Section 23 05 00 – COMMON WORK RESULTS FOR HVAC, for details on welder's qualification requirements.

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. For convenience, details and specifications have been based on product types as defined in MSS SP-58 and 69 where applicable, and, where not applicable, catalog numbers shown have been based on products by the listed manufacturers.

## 2.2 PIPING ATTACHMENTS

A. Individually Suspended Horizontal Rigid Piping or Tube Attachments:

1. Band type:

a. 1-1/4 inch diameter pipe size and less only.
b. Formed steel loop overlapped at top with rod sized hole or insert nut. With or without side insert closure.
c. MSS SP-58 type 5, 6, or 10.

2. Clevis type:

    a. Any size pipe or tubing.
    b. Formed steel bands top and bottom connected by sheer bolt.
    c. MSS SP-58 type 1.

3. Roller type:

    a. Any size pipe or tubing.

    b. Radiused or angled roller and steel axle; yoke for single hanger rod or end sockets for double rod applications. Designed to accommodate longitudinal movement through roller action.

    c. MSS SP-58 type 41 and 43.

4. Provide products by one of the following manufacturers:

    a. B-Line Systems, Inc., Highland Illinois, or equal
    b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
    c. Grinnell Corporation; Pipe Support Division, Cranston, Rhode Island, or equal.

B. Supported from below Horizontal Rigid Piping or Tube Attachments:

1. Split Ring type:

    a. 1-1/4 inch diameter pipe size and less only.

    b. Cast malleable iron split ring with steel pivot and bolt, cast boss on one side threaded for standard rod or pipe attachment. Designed to accommodate minimal longitudinal movement only.

    c. MSS SP-58 type 12.

2. Roller type:

    a. Any size pipe or tubing.

    b. Radiused or angled roller and steel axle with end sockets for double rod applications. Provide with U-bolt upper restraint. Designed to accommodate longitudinal movement through roller action.

    c. Roller MSS SP-58 type 41 and U-bolt MSS SP-58 type 24.

3. Provide products by one of the following manufacturers:

    a. B-Line Systems, Inc., Highland Illinois, or equal
    b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
    c. Grinnell Corporation; Pipe Support Division, Cranston, Rhode Island, or equal.

C. Group Supported or Suspended (Trapeze) Horizontal Rigid Piping or Tube Attachments (Common Support Beam):

1. Support frame or trapeze beam of load rated brackets or channel strut product.

2. U-Bolt type:

   a. Any size pipe or tubing.

   b. Insulation support system rests directly on beam or shim, with U-bolt or split strut clamp upper restraint. Designed to accommodate minimal longitudinal movement only.

   c. U-bolt MSS SP-58 type 24, Strut clamp similar to B-Line "B-2000" series.

3. Radius Roller type:

   a. Any size pipe or tubing.

   b. Radiused roller and steel axle with end sockets for double rod applications. Provide with U-bolt upper restraint. Designed to accommodate longitudinal movement through roller action.

   c. Roller MSS SP-58 type 41 and U-bolt MSS SP-58 type 24.

4. Angled Roller type:

   a. 6 inch diameter pipe size and less only.

   b. Angled rollers with steel axles and formed steel angle clips designed for channel strut mounting. Provide with U-bolt upper restraint. Designed to accommodate longitudinal movement through roller action.

   c. Roller similar to B-Line "B218" or "B219" and Strut clamp similar to B-Line "B-2000".

5. Provide products by one of the following manufacturers:

   a. B-Line Systems, Inc., Highland Illinois, or equal
   b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
   c. Grinnell Corporation; Pipe Support Division, Cranston, Rhode Island, or equal.

D. Individual Vertical Rigid Piping and Tube Attachments:

1. Split Ring type:

   a. 1-1/4 inch diameter pipe size and less only.

   b. Cast malleable iron split ring with steel pivot and bolt, cast boss on one side threaded for standard rod or pipe attachment. Designed to accommodate minimal longitudinal movement only.

c. MSS SP-58 type 12.

2. Provide products by one of the following manufacturers:

a. B-Line Systems, Inc., Highland Illinois, or equal
b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
c. Grinnell Corporation; Pipe Support Division, Cranston, Rhode Island, or equal.

E. Flexible Pipe, Tube, or Hose:

1. Lengths three feet and under to be supported by adjacent piping system.

2. Similar to attachments for rigid piping systems described above, with "V" notch bottom in lieu of radius, and associated continuous rigid trough angle of same material spanning between attachments.

F. Piping Insulation Protection Systems:

1. Pipe Insulation Shields:

a. One Piece:

1) Formed steel, minimum 18 gauge thickness, longer of 2 times diameter or 12-inch long minimum, and 180 degree circumference, sized for insulation thickness.

2) MSS SP-58/69 type 40.

b. Two Piece Sliding:

1) Manufactured two piece sliding shield system designed to accommodate thermal movement.

2) MSS SP-58/69 type 40 inner shield similar to one piece shield above adhered to pipe insulation, with second outer shield of formed steel, minimum 18 gauge thickness, one times diameter length 6-inch long minimum, and 180 degree circumference, sized to fit outside inner shield, with formed ribs to keep shield centered on support clevis or trapeze.

3) Inner and outer shields separated by layer of PTFE (Teflon), minimizing friction between shields and allowing minimum four inches controlled pipe movement relative to hanger without insulation damage or outer shield moving past the end of the inner shield.

2. Type "A" Insulation Protection System:

a. 1" piping and smaller only.
b. Provide one piece or two piece sliding shield as required by distance from piping anchors.

3. Type “B” Insulation Protection System:

   a. 1¼” through 8” heating piping only.

   b. Provide one piece or two piece sliding shield as required by distance from piping anchors.

   c. Pipe Support Insulation: High density (20 pcf). molded fiberglass blocks consisting of fiberglass wool and urea-phenolic resin cured binder. Provide number and size of support blocks as required to limit deflection to 1% and avoid long-term damage to vapor barrier, and as required for pipe size and insulation thickness, in accordance with manufacturer’s written guidelines and project details. Seal cut in piping insulation vapor barrier using manufacturer’s recommended matching tape. Similar to AHAMFAB H-Block" by ICA

4. Type “C” Insulation Protection System:

   a. Acceptable for any size heating or cooling piping.

   b. Manufacturer’s assembly consisting of insulation shield, high compressive strength insulation, and vapor barrier covering. May include hanger also.

   c. Hanger: As required above, secured to shield and support insulation.

   d. Insulation Shield: Provide one piece or two piece sliding shield as required by distance from piping anchors.

   e. High Compressive Strength Insulation: 180 or 360-degree circumference insulation insert formed of water resistance treated hydrous calcium silicate (untreated cal-sil not acceptable) or cellular glass insulation, same thickness as adjacent insulation.

   f. Vapor Barrier Covering: White kraft outer surface bonded to aluminum foil, sandwiching reinforcing fiberglass skrim yarn, permanently treated for fire and smoke safety and to prevent corrosion of the foil, with a vapor transmission perm rating of 0.02 or less. Seal to piping insulation vapor barrier using manufacturer’s recommended matching tape.

   g. Similar to Models “123”, “124", “1031”, and “4031” by ERICO/Michigan Hanger.

5. Provide products by one of the following manufacturers:

   a. B-Line Systems, Inc., Highland Illinois, or equal
   b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
   c. ICA Inc.; Lehighton, Pennsylvania, or equal.
   d. Buckaroos, Inc.

G. Pipe Alignment Guides:

1. Steel Spider Clamp Type.

   a. 2-1/2 inch diameter pipe size and larger.

b. Twin steel bands with formed radius to fit pipe, drilled for clamping bolts, welded extension “spider” wings sized to slide axially in matching welded and bolted outer housing ring with structural attachment legs.

c. Similar to “No. 650" and “No.651" by ERICO/Michigan Hanger

2. Provide products by one of the following manufacturers:

a. B-Line Systems, Inc., Highland Illinois, or equal
b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
c. Metraflex; Chicago, Illinois, or equal.

## 2.3 DUCT ATTACHMENTS

A. Per SMACNA Duct Manual standards for size, height, and location of ductwork, and as noted below.

1. Materials and corrosion resistance as listed above.

2. SMACNA load tables allow for no external loads on duct: provide for 200 lb external load on all duct hangers and supports. Increase hanger and support sizes from SMACNA tables accordingly:

a. Minimum band size 20ga. x 1 inch.
b. Duct 48” wide and larger; provide trapeze style support of metal channel framing or angle iron, suspended from threaded rods.

3. Hanger bands to extend down sides and turn under bottom 1 inch minimum for all duct sizes. Minimum (2) #10 sheet metal screws per hanger (one each on side and bottom), (2) screws minimum on sides for duct over 12 inches tall, 12 inches on center max.

4. Round exposed duct: hang from twin half round bands and rods, or as otherwise detailed.

## 2.4 BUILDING ATTACHMENTS

A. Structural Steel Connectors:

1. C-Clamp style:

a. FM approved, U.L. listed, steel or malleable iron C-clamp with hardened set screw and lock nut, tapped for rod size, typically eccentrically loads structure.
b. Hanger rod bypasses structure: MSS SP-58 type 19.
c. Hanger rod in line with set screw: MSS SP-58 type 23.

2. Center Loading Beam and Channel Clamp Style:

a. Forged or formed steel or malleable iron construction, beam clamps with connection for concentrically loading structure, of types as required by loading and configuration.

b. MSS SP-58 types 21, 27, 28, 29, and 30.

3. Pivoting or Adjustable Connection Style:

a. Structural welding lug with forged steel clevis, side beam bracket, or other appropriate pivoting beam clamps as required for sloped steel.
b. Use for sloped steel, where thermal movement requires pivot, where seismic controls requires non-moment building connection, and elsewhere as required.
c. MSS SP-58 types, 21 or 22 with 16 or 17, 34, 57 with 14, etc...

4. Provide products by one of the following manufacturers:

a. B-Line Systems, Inc., Highland Illinois, or equal
b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
c. Grinnell Corporation; Pipe Support Division, Cranston, Rhode Island, or equal.

B. Existing Concrete Connectors

1. Self-energizing tapered expansion bolt/sleeve: GSA specification FF-S-325, Group II, Type 3, Class 3, UL Listed, FM approved, complete with split expansion sleeve, washer, and hex head nut; similar to “Rawl Lok/Bolt” by Rawlplug.

2. Dual-Interlocking Expansion Wedge Stud: GSA specification FF-S-325, Group II, Type 4, Class 1, UL Listed, FM approved, complete with split expansion sleeve, washer, and hex head nut; similar to “Rawl-Stud” by Rawlplug.

3. Dual-Interlocking Expansion Wedge Threaded Rod Anchors: UL Listed, FM approved, complete with split expansion sleeve; similar to “Rod Hanger Wedge Anchor” by Rawlplug.

4. Provide products by one of the following manufacturers:

a. Hilti, Inc.; Tulsa, Oklahoma, or equal
b. Ramset/Red Head; Michigan City, Indiana, or equal
c. Rawlplug Co. Inc.; New Rochelle, New York, or equal.

C. Flanged Connectors:

1. Applicable for attachment to building steel, concrete, or wood.

2. Malleable iron flange base, with central threaded hole for connection to threaded rod and symmetrical side hole for securing to structure with appropriate fasteners, typically used with split rings, similar to “Model No. 365M" by ERICO/Michigan Hanger.

3. Pipe Stanchion Flanged Support Plate and Floor Stand: ASTM A-536 ductile iron support plate with 1” rolled thread adjustment stud and nut, or 1/4-inch carbon steel base plate welded to schedule 80 threaded steel pipe, designed for use with Stanchion Saddle style supports described above; similar to “PS1236 Redi-Jack Pipe Support” by Red Hed.

4. Provide products by one of the following manufacturers:

a. B-Line Systems, Inc., Highland Illinois, or equal

b. ERICO/Michigan Hanger Co.; Solon, Ohio, or equal
c. Red Hed; Lincoln, Rhode Island. or equal.

## 2.5 ROOF MOUNTED SUPPORTS

A. Roof Curbs: Double shell, galvanized steel, welded and painted, 1-1/2 inch minimum thickness, with pressure treated wood blocking, braced and fully insulated with rigid fiberglass insulation 3 PCF. Includes gasket at top of curb for airtight seal between curb and ventilator or fan. Provide raised cant, recessed, or flanged curb bottom to suit roof construction and insulation.

1. Steel Thickness: 20 gauge up to 36 inches, 18 gauge 38 to 72 inches, and 16 gauge over 72 inches. Provided with reinforcing and heavier gauge as required to adequately support weight load on curb; coordinate exact size with specified equipment.

2. Minimum height of curbs above finished roof:

   a. 12 inches for curbs supporting exhaust and relief air equipment.

3. Provide with pressure treated blocking, through bolted to structure with stainless steel fasteners, as required bringing base of curb into proper plane for installation. Blocking minimum width to be no less than blocking height. Refer to Division 1 section “Roof Rough Carpentry” for additional details.

4. Provide products by one of the following:

   a. Pate or equal
   b. Con-Fab or equal
   c. Thy-Curb or equal

B. Curb Adapters: Where shown on drawings, provide curb adapters to transition in size from existing curb to equipment provided as a part of this contract. Curb adapters of fully welded aluminum (12ga) or stainless steel (16ga) construction designed for continuous exposure to the elements. Provide with integral curb counter flashing and drip edge with minimum 2 inch downturn and quarter inch clearance to existing curb exterior on all sides and minimum two screws per side, sized for proper wind resistance, #12 ss screws minimum. Upper portion similar to Roof Curb above.

C. Non roofing penetration exterior duct supports:

1. Install per manufacturers recommendations, and as required to maintain roofing warranty. In general, assume installation on loose laid pad of PVC or EPDM reinforcement compatible with roofing, at least one half inch thick and 4 inches larger than support stand base. Provide base sizes load rated for distributing the supported weight at less than 2 psf. Include snow load as shown on code compliance drawings. Provide detailed duct support layout drawings and support size / weight / roof loading calculations in submittal for all non roofing penetration exterior duct supports.

2. Provide loose laid support stands with structural UV stabilized plastic (polypropylene, polycarbonate, FRP) or stainless steel deck base, with socket securing Hot Dipped galvanized or Stainless Steel channel duct support superstructure. Include mechanically bolted support angle clips, and cross member channels for both gravity support and uplift resistance. All fasteners to be stainless steel. Provide with radiused edges to protect roofing, drainage holes, and bolt down holes as required by seismic restraint system.

3. Sliding clamped height adjustment supports, adjustable as required to achieve duct slope and roof clearance required.

4. Similar to "PPH-D Enclosed" by PHP. Provide products by one of the following:

   a. B-Line Systems, Inc., Highland Illinois, or equal
   b. RTS by Eberl Iron Works, Buffalo, NY, or equal
   c. Miro Industries, Inc., Murray, Utah, or equal
   d. Portable Pipe Hangers (PHP) Systems and Design, Houston, Texas, or equal

D. Non roofing penetration pipe supports:

1. Install per manufacturers recommendations, and as required to maintain roofing warranty. In general, assume installation on loose laid pad of PVC or EPDM reinforcement compatible with roofing, at least one half inch thick and 4 inches larger than support stand base. Provide base sizes load rated for distributing the supported weight at less than 2psi. Provide detailed piping support layout drawings and support size / weight / roof loading calculations in submittal for all non roofing penetration pipe supports.

2. 2 inch nominal and smaller pipe:

   a. Loose laid pipe support stand with structural UV stabilized plastic (polypropylene, polycarbonate, FRP) deck base / roller housing, with load rated roller saddle running on nylon or SS bearing shaft. Provide with drainage holes, and bolt down holes as required by seismic restraint system.

   b. Provide matching height adjustment spacers to achieve pipe slope required.

   c. Manufacturer load rated as required.

   d. Similar to "Pillow Block Pipestand Model 3-R" by Miro Industries, SS8-R by PHP.

3. 2½ inch to 6-inch nominal pipe:

   a. Loose laid pipe support stand with structural UV stabilized plastic (polypropylene, polycarbonate, FRP) or stainless steel deck base and adjustment rod support, load rated roller saddle sized for pipe supported, and low friction corrosion resistant sleeve bearing inserts running on a stainless steel shaft. Provide with radiused edges to protect roofing, drainage holes, and bolt down holes as required by seismic restraint system.

b. Stainless steel threaded rod height adjustment roller supports, adjustable as required to achieve pipe slope and roof clearance required.

c. Where required height is larger than supported from below rollers allow, provide load rated channel frame and hanger system similar to PHP PSE-Custom.

d. Load rated as required for pipe supported.

e. Similar to “Pillow Block Pipestand” Models “X-RAHSS” by Miro Industries, PP10-xx by PHP.

4. Provide products by one of the following:

a. B-Line Systems, Inc., Highland Illinois, or equal
b. RTS by Eberl Iron Works, Buffalo, NY, or equal
c. Miro Industries, Inc., Murray, Utah, or equal
d. Portable Pipe Hangers (PHP) Systems and Design, Houston, Texas, or equal.

E. Combination Equipment / Pipe Penetration Curbs: Similar to Roof Curb combined with Pipe Curb Assembly, both as specified above, integrated with equipment platform. Includes solid pressure treated plywood equipment platform top with closed cell foam gaskets between platform and curb and 3-inch rigid fiberglass insulation below platform

1. Includes heavy gauge counter flashing, factory sealed to pipe penetration assembly with penetrations adequate for both mechanical and electrical system penetrations. Similar to "SCEB-5" by Pate.

2. Plywood deck minimum 1.5” thick. With steel rail reinforcing under as required for proper equipment securement. Secure deck to curb and stiffeners, with equipment secured through deck to stiffeners via captive SS nuts and bolts with exposed heads.

3. Provide products by one of the following:

a. Pate or equal
b. Con-Fab or equal
c. Thy-Curb or equal

## 2.6 MISCELLANEOUS COMPONENTS AND ACCESSORIES

A. Piping Anchor and Guide Bases:

1. Provide custom designed piping anchor and guide bases as required to properly transmit the piping reaction forces to the building structure.

2. Triangulate fabrication to transmit reaction forces to deck edge of structure or other approved anchorage. Submit fabrication details for approval for all such supports including verified coordinated dimensions of support components and building structure proposed for attachment.

3. Use structural steel plate and shapes of pipe wall thickness minimum, with pipe diameter leg dimension minimum, secured by welding or multiple bolts of the pipe's hanger rod size minimum. Increase dimensions as required due to excessive unsupported length (greater than 15 pipe diameters) or moment bearing (bending) design.

4. Secure to at least two structural members, using at least three points of attachment designed to transmit both longitudinal and lateral piping reaction forces.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

C. Threaded Rods, Bolts, Nuts, Washers, Metals, Hardware, and Miscellaneous Assembly Components:

1. Provide manufacturer's load rated fasteners with size, strength and corrosion resistance as required for the application.

2. Rods, bolts, machine screws: rolled forged ANSI B1 Class 2A or better thread, bolts and screws with heads as required by the application, length as required for full thread engagement of but minimal projection past receiving connector including building attachment, (double) nuts, equipment attachment, etc.

3. Nuts: heavy pattern where space permits and where subject to repeated operation, ANSI B1 Class 2B or better thread.

4. Washers: US pattern where space permits, SAE pattern otherwise, with toothed or split lock washer when attached to equipment with moving or vibrating parts.

5. Sheet metal screws: self drilling, thread forming, hardened steel (hardened SS as required), load rated screws with hex heads designed for power driving

6. Structural Steel: ASTM A 36/A 36M, carbon-steel, black and galvanized, and/or series 300 Stainless Steel plates, bars, angles, channels, and other shapes in thickness and size as required for load.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which hangers and supports are to be installed and notify Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in an acceptable manner.

1. When Contractor confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Architect written confirmation. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Contractor.

2. Identify any discrepancies between specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work required by discrepancies after installation at Contractor's expense.

## 3.2 GENERAL INSTALLATION

A. Provide complete hanger and support systems for piping and ductwork systems and equipment, including all necessary attachments, fasteners, threaded rods, bolts, miscellaneous hardware, and associated work as required.

B. Provide specified products, installed in accordance with applicable sections of this specification, in accordance with the manufacturer's recommended installation instructions, and as detailed on the Drawings.

C. Support pipe, duct, and equipment from the building structure.

1. Provide approved miscellaneous support structure as required to attach hangers and supports to building structure in conformance with all applicable standards and related specification sections.

2. Do not use chain, perforated hanger strapping or band, wire hangers, or kinked, bent, or otherwise damaged hangers and supports.

3. Do not support one pipe from another, one duct from another, pipe from duct or equipment, or any similar combination.

4. Install lateral bracing with pipe hangers and supports as required to prevent swaying.

5. Provide special hangers and supports as shown on the drawings, as required to suit existing conditions, and as required for proper installation of equipment.

D. Coordinate the installation with applied fireproofing and where possible install attachments to structure prior to fireproofing. Where prior installation is not possible, repair fireproofing as required.

1. Repair or replace any fireproofing removed or damaged during installation of components.
2. Ensure repaired or replacement fireproofing continuously matches or exceeds rating of adjacent fireproofing and ensure that all warranties are maintained.

E. Load Distribution: Install hangers and supports so that live and dead loads and stresses from movement will not be transmitted to connected equipment.

## 3.3 PIPE HANGER AND SUPPORT INSTALLATION

A. Comply with MSS SP-58 and MSS SP-89 and as specified below. Install hangers, supports, clamps, and attachments as required properly supporting piping from the building structure.

B. Trapeze Pipe-Hanger Installation: 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 manufactured slotted channel system or structural shapes selected for loads being supported.

C. Size piping attachments for insulated piping to fit outside insulation. Size piping attachments for un-insulated piping to fit outside diameter of pipe.

D. 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. Provide for slope of trapeze supported piping systems with adjustable individual piping attachments.

E. Accommodate thermal movement of piping systems.

1. 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.

2. Provide rods of sufficient length for ample swing. Hang rods from high points to allow maximum swing.

3. Hang piping so that rods are vertical at the design temperature.

4. Where length of rod and thermal expansion combine to cause more than 4 degrees angular movement of rod (or 1” lateral movement in a 12” rod), provide suitable linkage to permit swing and limit rods to tensile loading only, or, provide pipe roll.

5. Where length of rod and thermal expansion would combine to cause more than 10 degrees angular movement of rod (or 2” lateral movement in a 12” rod), provide pipe roll.

6. More thermal movement is expected as the straight line distance from piping anchor points increases. Unless unusually long hanging rod length allows swing as indicated above, provide pipe roll hangers and supports at or above the following distances from piping anchor points indicated on drawing or installed in field. Deviations from below values subject to pre-approval:

| Piping Service | Distance from Anchorage |
|---|---|
| a. Trapeze Steel with both Heating and Cooling Service | 20 ft. |

F. Pipe Hangers and Supports Spacing (Maximum):

1. Provide hanger or support as close as possible to and within 24 inches of any elbow.

2. Provide hanger or support on branch pipe within 24 inches of main at takeoff / tee.

3. All Horizontal / Sloped Heating and Cooling Piping Systems:

| Piping Material | Maximum spacing of hangers |
|---|---|
| a. Copper ¾ in. and smaller | 5 ft. |
| b. Copper 1 in. and 1-¼ in. | 6 ft. |
| c. Copper 1½ in. and larger | 8 ft. |
| d. Steel 2 in. and larger | 10 ft. |

G. Insulated Piping

1. Center insulation shields at piping attachments and secure shield from lateral movements by wrapping PVC tape around circumference of piping insulation and shield at both ends of shield.

2. At all piping attachments, provide piping insulation protection system of strength and configuration required to guarantee integrity of pipe insulation and associated vapor barrier. Refer also to SECTION 23 07 00 INSULATION.

## 3.4 BUILDING ATTACHEMENTS INSTALLATION

A. Threaded Rod for Hangers:

1. Double nut each end of each rod. Threaded clamp, turnbuckle, etc. counts as one nut.

2. Rod size for individual pipe hangers and two rod / two pipe or duct trapeze style supports:

| Rod size: | for Pipe size: | for Duct size: |
|---|---|---|
| 3/8” | 2” and smaller. | 48” wide to 72” |
| 1/2” | 2-1/2" and 3". | Over 72” wide |
| 5/8” | 4" and 5". | |
| 3/4” | 6". | |

3. For multiple pipe or duct trapeze style supports with two rods for more than two pipes or two or more ducts, size rods according to manufacturers recommended safe working loads taking into account total hung weight, 200 pound live load, as well as capacity of structure; each rod not smaller than size shown above for largest pipe or the sum of the duct width in the trapeze. Submit details of all such supports and connectors for approval before construction, including schedule of proposed sizes and capacities.

B. Fastener Systems: Provide screws, bolts, approved anchors, etc., to secure piping, duct, equipment, supports, and miscellaneous components and accessories to structure. Nailing not permitted.

1. Install all fastener systems and anchorage in strict accordance with fastener manufacturer's instructions and as otherwise indicated below.

2. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 3" 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.

3. Minimize eccentric loading of structure as follows:

    a. For paired point loads eccentrically suspended (C-clamp attached supply and return pipes, etc), suspend from opposite edges of structural member.

    b. For point loads over 400 pounds, use center loading beam clamps or other structurally concentric building attachment, and confirm proposed configuration with Engineer by submittal.

## 3.5 DUCT HANGERS AND SUPPORTS

A. Install per SMACNA duct manual and as modified by the requirements of this section.
B. Provide support spacing per building structural system but not greater than 8 feet. Provide extra support structure as required.

## 3.6 ELECTRICAL WORK HANGER AND SUPPORT INSTALLATION

A. Refer to Division 26 complete.

## 3.7 ROOFTOP SUPPORT INSTALLATION

A. Rooftop Supports for Piping, Duct, and Service Access:

1. Non-roofing penetration supports:

    a. Install per manufacturers recommendations, and as required to maintain roofing warranty. In general, assume that cleaning area of roofing at each support is required with installation on loose laid pad of PVC or EPDM reinforcement compatible with roofing, at least one half inch thick and minimum 4 inches larger than support stand base.

    b. Center supports beneath duct or pipe so cradle allows pipe to be squarely over and through cradle pipe stand. Align platform supports adjacent to equipment requiring service access as required provided optimized access.

    c. Adjust to desired height insuring level platforms, level horizontal bars, proper longitudinal pitch for pipe and duct, and even load distribution among all supports.

    d. Set equipment in support without dropping or causing undue impact. Assemble platform grating and secure to superstructure.

e. Assemble duct and piping restraints and make final adjustments to alignment and level.

2. Curb-Mounted-Type Pipe and Duct Supports: Assemble components and mount on permanent, stationary roof equipment support rails or curb.

B. Roof Curbs:

1. Maintain existing roof warranties. Contractor is responsible for the installation of all Roof Curbs for their equipment complete. Employ the services of a qualified subcontractor specializing in roofing work and certified by the carrier of all new or existing roofing warranties to perform warranty compliant roofing work as required for this project. Employ the services of a qualified subcontractor specializing in structural work to perform structural roof support work as required for this project. Use their services to cut roof openings, provide structural support and installation of Roof Curbs, Pipe Curbs, and Equipment Support Rails, and to patch roofing cuts complete. Refer to SECTION 01 73 00 - EXECUTION for additional requirements and procedures for cutting openings in existing roofs and roof decks.

a. If existing roofing is out of warranty, provide minimum two year warranty for roofing work of this contract.

2. Provide larger of curb height scheduled on Drawings or as recommended by equipment manufacturer, but not less than 12 in. above finished roof. Refer to required installation details and provide additional curb height where finished roof surface is above curb mounting flange.

3. Provide all roof curbs required for all rooftop-mounted equipment in Contract.

a. Provide structural support for roof deck around all roof curbs and roof deck penetrations 12 inch x 12 inch and larger, unless specifically indicated otherwise elsewhere on the Contract Documents. Align support frame with inner edge of curb. Refer to drawings for additional support details around roof openings.

b. Bolt curbs through blocking to structure with stainless steel fasteners, as required for seismic and wind movement control.

c. Verify exact size and location and set and secure unit to roof.

d. Set and secure curb or support level as required by manufacturer of equipment served and as required by the installation details of the seismic restraint system. Provide tapered shims as required up to 3-1/2 inch thick. If structure slopes more than 3-1/2 inch over length of curb, provide sloped curb to match structure so as to minimize shims. Provide corrosion-resistant fasteners as required to secure curbs to deck or structure, coordinate with subsequent roofing requirements.

e. Coordinate roof openings and set and secure curbs in ample time so as to avoid delay in construction schedule.

f. Prevent water entry into building. Provide roofing work as required to flash curbs. Provide counter flashing and gaskets with curb mounted equipment as required to keep water from entering curb. Provide temporary caps as required until permanent installation is made.

g. Install Curb Adapters in manner similar to how supported equipment is secured to curb. Provide complete with closed cell gaskets, minimum two stainless steel fasteners per side and additionally as required for equipment support.

## 3.8 METAL FRAMING AND EQUIPMENT SUPPORT INSTALLATION

A. Provide miscellaneous metal, beams, angles pipe bars, structural steel shapes, bases, braces, etc. accessories required to attach hangers and supports to walls, floors, structural members, etc. in conformance with Section 05 12 00 – "STRUCTURAL STEEL FRAMING".

B. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

C. Custom Hangers and Supports: Install as required by special circumstances encountered, in accordance with applicable details and layouts shown on Drawings, and as approved by Architect.

D. Provide lateral bracing to prevent swaying for equipment supports.

E. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

## 3.9 ADJUSTING

A. Adjust all hangers and supports after installation of piping and associated equipment to distribute loads equally on attachments and to achieve proper pitch for the applicable piping system.

B. Trim excess length of continuous-thread hanger and support rods as required - avoid hazardous protrusion.

## 3.10 PAINTING AND TOUCHUP

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.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29

# SECTION 23 05 43 – MECHANICAL VIBRATION AND MOVEMENT CONTROL

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes mechanical movement controls for all mechanical equipment and components, piping, and duct work provided or modified as a part of this Project and as noted on the drawings, whether movement is from sound, vibration, thermal, or other sources including (but not limited to):

1. Vibration isolation hangers and mounts for equipment, piping, and ductwork.
2. Flexible piping and flexible piping connections.

### 1.3 DEFINITIONS

A. IBC: International Building Code.
B. ICC-ES: ICC-Evaluation Service.

### 1.4 PERFORMANCE REQUIREMENTS

A. Provide mechanical sound, vibration, and movement control for all mechanical equipment, piping, duct work, and other components provided or modified as a part of this Project, and as shown on the Drawings. Mount on or suspend from vibration isolators to reduce transmission of vibration and mechanically transmitted sound to building structure. Select vibration isolators in accordance with weight distribution to produce reasonably uniform deflections.

1. Correct any variance or non-compliance with specified requirements in manner directed by Architect.

### 1.5 SUBMITTALS

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

B. Action Submittals:

1. Product Data for the following:

a. Catalog cuts and data sheets on vibration isolators. Indicate rated load, rated deflection, and overload capacity for each device. Annotate to indicate application of each product submitted and compliance with requirements.

2. Shop Drawings

a. Submit details of following items

1) Equipment bases including dimensions, structural member sizes and support point locations. Equipment bases shall include all curbs for rooftop air handling units.

2) Isolation hangers and systems for ceiling hung equipment, piping and ductwork.

3) Complete flexible connector details.

b. Indicate deflections and model numbers on all hanger, mounting or pad drawings including any other specified requirements.

c. Provide in tabular form spring diameters, rated loads and deflections, heights at rated load and closed height for all springs shown in submittals.

C. Informational Submittals:

1. Product Certificates:

a. Contractor Statement of Responsibility: Refer to Division 01 Section, “Quality Requirements”.

D. Closeout Submittals:

1. Field quality-control test reports.

2. Contract Closeout Submittals: Comply with requirements of Section 01 73 00, including submission of operating and maintenance instructions as item in "General Construction Instructions" manual described in that section.

## 1.6 COORDINATION

A. Coordinate layout and installation of vibration isolation and movement control devices with other construction that penetrates ceilings or is supported by, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

# PART 2 - PRODUCTS

## 2.1 VIBRATION ISOLATORS

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. Amber/Booth Company, Inc.
2. Kinetics Noise Control.
3. Mason Industries.

B. Where neoprene is referred to and used in vibration isolation components, it shall be bridge-bearing grade premium neoprene of the durometer hardness grade and size specifically recommended by the design make manufacturer for both maximum vibration isolation and load rated for the specific application.

C. Hangers

1. Neoprene Hangers: Rigid steel frames containing neoprene element.

a. Minimum 1-1/4-inch thick neoprene element on bottom with projecting bushing preventing steel-to-steel contact.
b. Minimum static deflection of 0.20-inch.
c. Boxes not articulated, clearance hole in neoprene element to allow non-moment bearing connection at structural support.
d. Configured for threaded rod, eye bolt, or strap connections as required.
e. Basis-of-Design Product: Mason Industries, Inc.; Type HD.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and movement control devices for compliance with requirements for installation tolerances and other conditions affecting performance. Notify affected Prime Contractors and Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in an acceptable manner.

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

2. Identify any discrepancies between specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work required by discrepancies after installation at Contractor's expense.

B. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

### 3.2 VIBRATION, SOUND, AND THERMAL MOVEMENT CONTROL INSTALLATIONS

A. Install all vibration isolators in strict accordance with manufacturers written instructions and all submittal data. Coordinate installation to avoid rigid contact with building.

1. Install without any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

2. Do not make rigid connections between equipment and building structure that degrade noise and vibration control system specified.

3. Do not install any equipment, piping, duct, or conduit with rigid connections to building or other support structure unless no isolation is specifically called for. "Building" includes, but is not limited to, roof deck, floor/ceiling/roof slabs, beams, joists, columns, studs and walls.

4. Identify any conflicts which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions to Architect / Engineer prior to installation. Corrective work required by conflicts after installation at Contractor's expense.

5. Correct, at no additional cost, all installations deemed defective in workmanship and materials at Contractor's expense.

## 3.3 AIRSIDE INSTALLATIONS

A. Vibration Isolation of Air Handling Equipment:

1. Isolate all suspended equipment using neoprene hangers with minimum 2 inches spring deflection for units having 1/2 KW motors and larger and with minimum 1 inch spring deflection for units having less than 1/2 KW motors.

END OF SECTION 23 05 43

# SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Testing, Adjusting, and Balancing (TAB) Work shall be a joint effort of the Contractor and the TAB Agency, performed with the intention of leaving the systems involved in a properly functioning and balanced flow condition as designed and indicated in the Construction Documents, similar to the "Total System Balance" condition described in the AABC Standard.

1. The division of responsibility for the TAB Work is outlined below. Contractor to perform preparation and ancillary work described below, with the option of subcontracting a portion of their work to the TAB Agency, but the TAB Agency must take sole responsibility for any portion of the preparation or TAB Work defined as the TAB Agency's Work.

2. TAB Agency Work to be performed by a fully qualified independent TAB Agency as described in quality assurance below and as approved by the Architects and Engineers, to be paid for by the Contractor responsible for HVAC Work as a first tier subcontract to their work.

B. Section includes preparation for, and Testing, Adjusting, and Balancing (TAB Work) of HVAC components, equipment, and systems:

1. Contractor Preparation and Participation:

a. Place systems in satisfactory operating condition as detailed below prior to the arrival of the TAB Agency for the specified TAB Work, and notify the TAB agency, Construction Manager, and Engineer in writing when systems are ready for TAB Work.

b. Attend and actively participate in coordination and TAB meetings.

c. Keep TAB Agency apprised of construction schedule as required facilitating TAB agency job site visits prior to concealment of work. Provide overall construction schedule to TAB agency at coordination meetings and TAB meetings, update schedule regularly noting milestones and dates affecting TAB review and work schedule, and provide at minimum 7 calendar days notice prior to concealment.

d. Coordinate and provide mechanical and controls systems operation, revisions, and other ancillary work as required during TAB Work, as detailed below.

e. Make changes as required to create a testable, balanceable system, as recommended by TAB agency but only as approved by the Engineer.

2. TAB Agency Preparation:

a. Review Construction Documents and Coordination Drawings with Engineer, Construction Manager, and Contractor and assist in preparation of submittals, particularly Coordination Drawings, dampers, and balancing valves, by preparing recommendations to Contractor and Engineer on locations of balancing valves, dampers, access doors, test connections, etc., as well as any other special considerations affecting the TAB Work and/or the fabrication or engineering of the systems. Documentation of assistance shall be both by mutually agreed upon notations on the submittals / sheet metal Shop Drawings prior to submittal, and by TAB Agency's letter accompanying submittal, verifying review and TAB Agency approval of the specific submittal.

b. Visit job prior to concealment of work, repeatedly if necessary due to construction scheduling, check work, and advise the Contractor, Construction Manager, and Engineer on correctness of locations of dampers, access doors, test connections, etc., as well as any other special considerations affecting the TAB work. Advise in writing, copied to the Contractor, Construction Manager, and the Engineer within 3 days of the site visit but in any event before concealment.

C. TAB Work includes:

1. *Testing* of all mechanical components for performance, calibration, capacity, and other characteristics as outlined below and as required, demonstrating conformance with contract documents and submittals.

2. *Adjusting and Balancing* of all mechanical components of this project as described in the contract documents, achieving specified air and water flow at all terminal equipment, distribution at lowest noise levels and energy use, and achieving specified thermometer, gauge, and sensor instrument accuracy and calibration, all as outlined below.

3. Documentation, correspondence, data recording, reporting, and demonstration all as outlined below and elsewhere in the contract documents.

4. *Coordination* with other Contractors, subcontractors, Construction Manager, Owner's Representatives, and Architect / Engineer as required achieving specified TAB results.

## 1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.
B. ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers
C. Contractor: The entity contracted to perform the HVAC Work described in these contract documents.
D. NEBB: National Environmental Balancing Bureau.
E. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
F. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

G. TAB: Testing, adjusting, and balancing.
H. TABB: Testing, Adjusting, and Balancing Bureau.
I. TAB Agency: An entity engaged to perform TAB Work who is qualified and approved to do so as described below.

## 1.4 SUBMITTALS, GENERAL

A. Contractor:

1. Prior to submittal of any equipment affecting TAB Agency, review with TAB Agency and obtain commentary and approval as described in “Summary” Article. Include TAB Agency review commentary with affected submittals.

2. Immediately upon approval of other submittals, provide the TAB Agency with copies of approved submittals, including Shop Drawings of all hydronic and air systems and equipment requiring balancing.

## 1.5 ACTION SUBMITTALS

A. Contractor:

1. Perform no work affecting TAB prior to TAB Agency approval.
2. Within 30 days after award of Contract, submit TAB Agency qualifications proposal for approval.

B. TAB Agency:

1. Submit TAB Agency qualifications proposal for approval.

   a. Name and contact information of proposed TAB Agency,
   b. Documentation that they meet the qualifications specified in "Quality Assurance" Article,
   c. Evidence of current TAB Agency and TAB Supervisor Certification,
   d. List of instruments to be used in testing and balancing, with current certification of all instruments’ calibration,
   e. Examples of data forms proposed for each system type showing input cells for this Project’s required data,
   f. 3 regional references for comparable recent jobs.

2. Submit Strategies and Procedures Plan: Within 30 days of Architect’s approval of TAB Agency, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

3. Submit Preliminary Partial TAB Reports.

4. Submit Certified Final TAB Report.

5. Certified Six Month System Check / Design Condition TAB Report.

## 1.6 INFORMATIONAL SUBMITTAL

A. Contractor and TAB Agency:

1. Systems Readiness Report as described more fully below.

B. TAB Agency:

1. Instrument Calibration Reports: Include the following on calibration agency letterhead:

   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.
   f. Test data points over range qualified – standards and measured values.

2. Contract Documents Examination Report: Within 15 days of Architect's approval of TAB Agency, submit the Contract Document Examination Report as specified in Part 3.

3. Include commentary with all Contractor submittals affecting TAB work as described above.

4. Pre-Construction Inspection and Testing Report: Prior to removal of any affected construction.

## 1.7 QUALITY ASSURANCE

A. TAB Agency, Employee, and TAB Work Qualifications:

1. TAB Agency: Fully certified current member of "Associated Air Balance Council" (AABC), "National Environmental Balancing Bureau" (NEBB), or "Testing, Adjusting, and Balancing Bureau" (TABB), specializing in the adjusting and balancing as specified in this Section of systems as specified and as shown on the Contract Documents, with minimum three years documented experience as a fully certified member, and three current regional references for projects of comparable scope.

2. TAB Field Supervisor: Employee of the TAB Agency and currently certified by AABC, NEBB, or TABB as a Testing, Balancing and Adjusting Supervisor.

3. TAB Technician: Employee of the TAB Agency and currently certified by AABC, NEBB, or TABB as a TAB technician.

4. All TAB Work: Performed by direct employees of the TAB Agency, who are either TAB Field Supervisors themselves, or who are TAB Technicians working under the direct supervision of a TAB Field Supervisor.

B. Conform to basic procedures and methods outlined by applicable publications in testing and balancing of air and water systems by the following organizations, and as modified by this document:

1. Associated Air Balance Council (AABC).
2. National Environmental Balancing Bureau (NEBB).
3. Testing, Adjusting, and Balancing Bureau (TABB).
4. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
5. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
6. Individual manufacturer requirements and recommendations.

C. TAB Report Data Forms: Follow AABC, NEBB, TABB, or SMACNA format as modified by the data requirements of this Project, subject to submittal approval.

D. 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.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: Instruments as described in ASHRAE 111, Section 5, "Instrumentation.", all currently certified as calibrated by a NRTL or NVLAP in accordance with Division 01 Section “Quality Requirements”.

F. Contractor: maintain qualified personnel at Project for system operation, trouble-shooting, making system changes, and performing mechanical adjustments in conjunction with TAB procedures.

## 1.8 PROJECT CONDITIONS

A. Environmental Requirements: Accomplish TAB work under appropriate outdoor temperature conditions.
B. Concealed Conditions: Before concealment of systems, verify and advise on type and location of balancing devices and test points. Make changes as required to balancing facilities.

## 1.9 COORDINATION AND SCHEDULING

A. Refer to Division 00 and Division 01 for overall project sequencing and scheduling requirements. All HVAC work required for, and, approvable balancing in accordance with the requirements of this section is required to be complete before Contract Substantial Completion.

1. Contractor: Assure that all HVAC work required to properly and completely test and balance the various systems, occurs in a timely fashion coordinated with the overall project schedule as required, with final readiness reported at minimum two calendar weeks prior to contract scheduled Substantial Completion Date. For HVAC Work required to be performed simultaneous with TAB Work, coordinate schedule with TAB agency and provide qualified staffing as required keeping pace with TAB agency personnel. Coordinate and report partial systems readiness to TAB agency to allow TAB work to proceed in an orderly fashion.

2. TAB Agency: Assure that all TAB Work and all subsequent reporting on same occurs in a timely fashion coordinated with the overall project schedule prior to contract scheduled Substantial Completion Date. For HVAC Work required to be performed simultaneous with TAB Work, coordinate schedule with Contractor and provide qualified staffing as required to complete TAB work and reporting within two calendar weeks of final HVAC systems readiness for TAB.

B. Tab Agency: Coordinate, schedule, and run a TAB Strategies and Procedures meeting, with Contractor, Owner, Architect, Engineer, Controls Subcontractor, and Commissioning Agent all present. Provide TAB Plan and agenda in advance, and produce and distribute meeting minutes.

C. Contractor and TAB Agency: Perform all examination and preparation work required and submit Systems Readiness Report(s) prior to beginning TAB work.

D. Contractor and TAB Agency: After submission of Systems Readiness Report, coordinate and schedule all preparation and TAB work with each other, Architect/Engineer, Construction Manager, Commissioning Agent, and Owner,. Notify O/AE/CM/Cx team of all scheduled TAB work test dates and times in writing with at least seven days' advance notice for each visit.

1. Cooperate with other contractors and affected subcontractors as required to provide complete and proper testing, adjusting, and balancing of HVAC systems.

E. Accomplish TAB Work during construction period as soon as the systems are complete enough to perform TAB work. Coordinate with project phases and before Owner takes possession. TAB work and approval of at least partial pencil copy reports is required before Owner takes possession.

F. Multiple visits will be required for phased construction in cooperation with construction schedule, with multiple “pencil copy” submittals of partial TAB reports required promptly as each phase of TAB work is accomplished.

G. Perform balancing for record at final stage when all previously completed sub-systems are checked and re-balanced to design performance.

H. Contractor and TAB Agency: return to the site approximately six months after initial TAB Work is complete to perform system checkup and design condition rebalancing as defined below.

I. Contractor and TAB Agency are subject to recall to site to verify report information before acceptance of the report by the Architect.

J. Contractor: provide 2 additional copies of Shop Drawings and other submittals for all equipment and systems to be tested and balanced to TAB Agency as soon as possible but no later than 60 days prior to scheduled completion of equipment and systems installation.

K. TAB Agency:

1. Verify that Contractor has placed all systems and equipment in satisfactory operating condition as required allowing TAB Work to be properly performed.

2. Cooperate with Contractor and affected subcontractors as required to provide complete and proper testing, adjusting, and balancing of air and water systems.

3. Visit Project prior to concealment of Work and note location of dampers, test connections, and similar items. Record this information, transmit to Contractor, and incorporate on Record Drawings.

4. Coordinate timing of six month system check and design condition TAB Work with weather, Contractor, and Owner.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT

A. TAB Agency: Provide tools, ladders, recording meters, gauges, thermometers, velometers, anemometers, Pitot tubes, inclined gauge manometers, magnehelic gauges, amprobes, voltmeters, psychrometers, tachometers, ultrasonic or other non-intrusive flowmeters, and all other instrumentation required to perform specified TAB work. Accurately calibrate all instruments.

1. Make instruments available to Architect to facilitate spot checks during testing and back-checking.
2. Provide additional balancing devices as required.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. By TAB Agency:

1. 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.

2. Visit Site and examine existing systems before construction and new / re-worked systems prior to concealment of construction to check on and advise regarding location of installed balancing devices, such as test ports, gage cocks, thermometer wells, thermometers and gages, flow-control devices, balancing valves and fittings, volume dampers, test connections, etc. Verify that locations of these balancing devices are accessible. TAB Agency shall advise Contractor and Architect of TAB Agency findings by letter.

3. Examine the submittals for HVAC systems and equipment. Verify that proposed equipment can be balanced as specified and as required. Provide commentary on all submittals advising where additional balancing devices are needed or configuration adjustment is desired to facilitate TAB work.

4. 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.

5. Examine test reports specified in individual system and equipment Sections.

6. Examine manufacturer's equipment performance data including pump and fan curves.

   a. 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.

B. By Contractor:

1. Examine systems and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections has been performed, and all TAB preparation as described in "Preparation" Article is complete.

## 3.2 PREPARATION

A. TAB Agency:

1. Prepare a TAB plan that includes site specific strategies and step-by-step procedures with this project's equipment identified.

B. Contractor: Before TAB work commences on any portion of the system, and before new system startup, verify that systems are complete and in proper operating condition. Ensure the following:

1. Equipment is operable, in a safe and normal condition, and is of the size and capacity specified in the Contract Documents, bearings are greased, are aligned and properly tight, and equipment with functioning controls is ready for operation. Required modifications to systems shall be made in advance of the TAB Agency's arrival for that portion of the work.

2. Provide proper equipment start-up as specified, complete with manufacturer's filled out standard published start-up forms.

3. Temperature control systems are operable to the extent required for that portion of the TAB Work. Control valves must at least be installed complete and hand operable. Automatic dampers must be operable and under control. Safety interlocks and controls on HVAC equipment must be properly functional.

4. All motors, and fans have correct rotation.

5. Access doors necessary to reach duct volume dampers, balancing valves, and measuring stations are installed in accessible locations and are operable.

6. As-built conditions are accurately recorded on working as-built drawings, including locations of all access points, manual and automatic dampers, isolation, balancing, and control valves, fittings, and all other items affecting TAB work. Provide copies of these annotated as-built drawings for TAB agency's use during TAB work.

C. Contractor:

1. Prepare and submit Systems Readiness Reports to Engineer, Commissioning Agent, and TAB Agency, with itemized checklists of the above items as appropriate for the equipment to receive TAB Work, with a column for Contractor indicated status and another with room for TAB Agency commentary, itemizing any remaining deficiencies discovered and confirming all systems preparation and examination has been properly performed.

    a. Include itemized list of all examination and preparation procedures outlined above and as otherwise required by TAB Agency's procedures, with initialed dated verification of each item by authorized responsible party.

    b. Promptly report abnormal conditions in mechanical systems or conditions that prevent system balance. If, for design reasons, system cannot be properly balanced, report as soon as observed.

2. Report any defects or deficiencies observed during performance of TAB procedures.

D. TAB Agency:

1. Review, edit, and submit annotated Contractors Systems Readiness Reports to Contractor, Engineer, and Commissioning Agent, with itemized TAB Agency concurrence or commentary, itemizing deficiencies discovered and confirming all systems preparation and examination has been properly performed, with initialed dated verification of each item by authorized responsible party.

    a. Report abnormal conditions in mechanical systems or conditions that prevent system balance within 24 hours of discovery. If, for design reasons, system cannot be properly balanced, report as soon as observed.

2. Report any defects or deficiencies observed during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values. Include updates in partial TAB report submittals. Adjust as-built drawings as required to accurately reflect deviations from draft as-built set.

3. Promptly report abnormal conditions in mechanical systems or conditions that prevent system balance. If, for design reasons, system cannot be properly balanced, report as soon as observed.

## 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. In the following TAB procedures portions of Part 3 Execution of this document, the procedures are deemed to be TAB Agency work unless specifically identified as Contractor work.

B. Contractor required assistance and Ancillary Work during TAB Agency Work includes the following general work categories and notes on Contractor Work requirements in subsequent specific procedure descriptions:

1. Maintain mechanically qualified personnel at Site to perform necessary mechanical modifications and adjustments in conjunction with TAB procedures.

2. Operate systems.

3. Provide trouble-shooting.

4. Cut insulation, pipes, ducts, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. Properly plug all holes. Provide new insulation that matches removed materials, finished in accordance with Division 23 Section "HVAC Insulation."

5. Change air filters as required.

6. Adjust automatic damper linkages so they all operate smoothly and close tightly.

7. Perform necessary controls operations required for TAB procedures.

8. Re-adjust / make final adjustments to registers, grilles, and diffusers in cooperation with Owner and TAB Agency as required to obtain uniform space temperatures and air movement free from objectionable drafts and noise. As this affects system pressure drops, this must be completed before final airflow balancing.

9. Make any required additions or changes in types, locations, etc., of balancing equipment.

10. Provide other mechanical adjustments as required in conjunction with TAB procedures.

11. Leave system in proper working order, closing access doors, closing doors to electrical switch boxes and securing cover plates, restoring thermostats to specified settings, restoring systems to automatic operation as required, replacing ceiling tiles, plugging access ports and repairing insulation, cleaning, etc...

C. Tab Agency: 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", or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing."

2. Provide all testing and Balancing as required by the specific procedures outlined below and as required to provide the final test report as described below.

3. Mark equipment and balancing devices, valve position indicators, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

4. Take and report testing and balancing measurements in inch-pound (IP) units.

## 3.4 GENERAL PROCEDURES: AIR SYSTEMS TESTING, ADJUSTING, AND BALANCING

A. Visit Site prior to concealment of construction to check and advise regarding location of dampers, test connections, etc. TAB Agency shall advise Contractor and Architect of TAB Agency findings by letter.

B. Review sheet metal shop drawings and mark locations of all required balancing dampers before duct fabrication.

C. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct in such a manner that local flow dynamics have a negligible effect on the measurements. Use multiple, bidirectional, traverses if flow measurements cannot be made in a section with at least 8 diameters straight duct upstream and 4 diameters of straight duct downstream from the measuring station. Mark all traverse locations on plans in report.

D. After adjustments, take measurements to verify balance has not been disrupted. Verify that disruptions in balance have been corrected.

E. Permanently mark valve, damper, and other adjustment device settings at devices to simplify restoration of settings. Record settings and include in report. Set and lock memory stops.

F. Procedures:

1. Verify that all systems are complete and operable as scheduled.

2. Verify that registers, grilles, and diffusers are adjusted to obtain uniform space temperatures and air movement free from objectionable drafts and noise. Cooperate with Owner and Contractor and reach agreement on air distribution pattern before proceeding.

3. Provide temporary filter media as follows: with the system fully operational, all dampers open, and the fan running at the scheduled RPM, check submittal values for new, midlife, and final/clogged filter pressure drops, check and record air pressure drop across the new clean final design filters, and provide temporary media to approximate midlife pressure drop across the filters for use during balancing. Record and report both pressure drop values at the final design flowrates. Adjust filter differential pressure switches to trip at correct final/clogged filter pressure drop in cooperation with Energy Management and Control System manufacturer's representative.

4. With the system fully operational, all dampers open, and the fan running at the approved submittal RPM, measure the airflow through all terminal units as well as the total system volume, without making any adjustments, and formulate a plan for preliminary adjustments of dampers and fan speed. Terminal units shall be defined to include all diffusers, registers, grilles, duct entries, louvers, hoods, etc.; i.e., wherever air enters or leaves ductwork whether indoors or outdoors. Record and report all initial values.

5. In cooperation with Energy Management and Control System manufacturer's representative, make mechanical adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Adjust and set the extreme operating conditions of these dampers and check completed damper control operations for proper calibration, reporting to control installers conflicts with those requiring adjustment. Test leakage of closed dampers. Adjust and set intermediate positions of outside air and return air dampers as required to achieve design outside airflow requirements defined in the sequence of operations, and / or calibrate outside air flow meters at this point. Balance variable volume systems at maximum air flow rate with full cooling and at minimum air flow rate with full heating

6. Adjust terminal units to the proportionally correct cfm, not necessarily the design cfm.

    a. If all the dampers in a branch line's terminal units must be adjusted to limit cfm, then use the branch line volume damper to limit the pressure drop across the terminal units in that branch so that at least one terminal unit's damper remains wide open but still has the correct flow. Adjust all branch ducts to proper proportional cfm in this way, leaving the volume dampers in the flow limiting branches wide open.

    b. Provide branch duct volume control by duct internal devices such as dampers and splitters only to the extent that the most open damper or splitter remains wide open and adjustments do not create objectionable air motion or sound levels. Under no circumstances shall total air system volume be throttled back to design flow through the partial closing of all dampers and splitters.

    c. Record and report all initial adjustment positions and proportional flowrates achieved.

7. Vary total air system flowrate by adjustment of fan speeds. Provide drive changes required.

    a. For variable frequency drive fans, perform the following procedure:

    b. With the VSD set to bypass mode or set at 60 Hz, as described above to achieve the design system cfm, with bypass dampers etc. closed or otherwise in the maximum resistance position.

    c. Adjust the VSD to the maximum non- overloading frequency for the system, and measure and report the flowrate at this frequency

    d. If other specific air flow rates are required due to the sequence of operations as reported on the drawings or in Section 23 09 00 – Instrumentation and Control for HVAC, coordinate with these requirements and determine the required frequency - flow relationships

8. Verify that all terminal units are at the design cfm to within the balancing tolerance, and if not, repeat steps f. and g. above until design conditions are satisfied.

9. Test and record final motor, drive, air moving equipment, exhaust fan, damper, and terminal unit information at this point.

10. After all air flow rates are tested, adjusted, and balanced, test the performance of all air to air energy recovery equipment. Test the performance of air to air energy recovery equipment only when the outside air and inside air temperatures are close enough to summer or winter design conditions to verify performance. Test under either summer or winter conditions; if design conditions cannot be met during initial TAB work due to timing, provide energy recovery core testing under true design conditions at the six month system check. Include all data as specified above in reports.

11. Test and record air heating and cooling coil information after this point, as follows:

    a. Perform this step in conjunction with hydronic system balancing and after cooling and heating systems are operational.

    b. Set hydronic control valve to fully open at design flow and temperature as described below. Allow cooling coils to become fully wet with condensation. Test temperatures outside of the line of sight to the coil.

    c. Test and adjust coil performance for all data indicated to be on report test sheets.

## 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 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, 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. Re-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.

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 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.

7. 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.

## 3.7 PROCEDURES FOR MULTIZONE SYSTEMS

A. Set unit at maximum airflow through the cooling coil.
B. Adjust each zone's balancing damper to achieve indicated airflow within the zone.

## 3.8 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 steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. 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.

## 3.9 PROCEDURE FOR MISCELLANEOUS DEVICE TESTING

A. Test and adjust all devices on project as required to correctly report the data listed below under paragraph on final report.

## 3.10 TOLERANCES

A. Adjust system totals to the sum of the connected load (plus leakage for air systems) rather than the scheduled pump or fan capacity.

B. Adjust air handling systems as follows:

1. Main ducts (ie. each fan system) to within minus 5 percent and plus 10 percent of the design values.
2. Outside air flow tolerance shall be at minimum that scheduled, with a tolerance of minus 0 percent and plus 10 percent.
3. Branch ducts and terminal units to within plus or minus10 percent of the design flow.
4. A total maximum variation of 10 percent between terminal units designated as “typical of (#)”.

C. Adjust hydronic systems as follows:

1. Each existing pump where indicated on Drawings to within 5 percent of the design flow values.
2. Branch lines and radiation to within 10 percent of the design flow values
3. A total maximum variation of 10 percent between terminal units designated as “typical of (#)”

## 3.11 PRELIMINARY REPORTING

A. Contract Document Examination Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for proper systems' balancing. 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. Pre-Construction Inspection and Testing Report: Prior to removal of any affected construction, prepare and submit report outlining results of Pre-Construction Inspection and Testing as outlined above and on the contract drawings.

C. Status Reports: Prepare biweekly 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.

## 3.12 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. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. 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. Settings for supply-air, static-pressure controller.
    e. 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 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 Moving Equipment (FCU, ERU, UV, F):

1. Location

2. Manufacturer

3. Model

4. Air flow, specified and actual

5. Return air flow, specified and actual

6. Outside air flow, specified and actual

7. Total static pressure (total external), specified and actual

8. Labeled diagram showing pressure drop across each internal component including dampers, filters, coils, diffusers, and blowers. Provide multiple readings for complex systems with multiple internal dampers affecting system pressure drops, under all specified modes of operation.

9. Inlet pressure

10. Discharge pressure

11. Applicable data as specified elsewhere including coil, motor, damper, and drive data.

12. Fan RPM ( for VSD driven fans, under various design conditions including at least full heating, 100% OA economizer, and full cooling loads)

F. Exhaust Fan Data (F):

1. Location
2. Manufacturer
3. Model
4. Air flow, specified and actual
5. Total static pressure (total external), specified and actual
6. Inlet pressure
7. Discharge pressure
8. Fan motor and drive data
9. Fan RPM( for VSD driven fans, under various design conditions including at least full heating, 100% OA economizer, and full cooling loads).

G. 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 deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.

f. Entering-air, wet- and dry-bulb temperatures in deg F .
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.

H. 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 deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

I. Gas- 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.

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.

c. Leaving-air temperature in deg F.
d. Air temperature differential in deg 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 deg 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.

J. Round 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 deg 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 deg F.

L. Electric Motors:

1. Manufacturer
2. HP/BHP
3. Phase, voltage, amperage (nameplate, actual, and no load)
4. RPM
5. Service factor
6. Starter size, rating, heater elements

M. Automatic Air Dampers (AAD, TBAAD, or internal to air moving equipment):

1. Location

2. Manufacturer

3. Model

4. Airflow, specified and actual.

5. Check closed position leakage and report.

6. Damper and/or actuator position at all required positions, along with associated controls signal required to achieve position. Coordinate required positions of return air and outside air ventilation control dampers with positions required by required ventilation rates. Refer to SECTION 23 09 00 – INSTRUMENTATION AND CONTROLS FOR HVAC, and coordinate damper position adjustment with temperature controls and Owner's required occupancy schedule.

7. Total static pressure drop at all required positions.

N. Manual Air Volume Dampers (VD, or shown with no text as: ⊺ ):

1. Location.
2. Report final damper position as angular deviation of blades from axial, with 0° being fully open and 90° being closed. Mark this position on duct at damper also.
3. Total static pressure drop across damper in as balanced condition.

O. Air Distribution Test Sheet (registers, grilles, and diffusers):

1. Air terminal number
2. Room number/location
3. Space Temperature
4. Terminal type
5. Terminal size
6. Area factor
7. Design velocity
8. Design air flow

9. Test (initial, adjusted, and final) velocities
10. Test (initial, adjusted, and final) air flows
11. Percent of design air flow

P. Louvers:

1. Air terminal number / drawing designation
2. Room number/location
3. Terminal type
4. Terminal size
5. Free Area
6. Design velocity
7. Test (final) velocity
8. Design air flow
9. Test (final) air flow
10. Percent of design air flow
11. Design Pressure drop
12. Test (final) pressure drop

Q. Automatic Balancing Valves Reports:

1. Identification/station
2. Location
3. Size
4. Manufacturer
5. Model
6. Design flow rate
7. Functional pressure drop range.
8. Actual/final pressure drop at system full flow condition.

R. Hydronic Control Valves Reports:

1. Location
2. Manufacturer
3. Model
4. Flowrate, specified and actual.
5. Pressure drop at full flow condition.

S. Controls Sensors Reports:

1. Coordinate work with Energy Management and Control System.

2. Test all controls system temperature, pressure, air monitoring ($CO_2$, CO, combustible gasses, humidity, etc.), and electrical current analog sensors for mid normal operating range accuracy. Adjust where applicable.

3. Test all controls system temperature, pressure, air monitoring ($CO_2$, CO, combustible gasses, humidity, etc.), and electrical current digital (on/off) sensors/switches for trip point. Adjust where applicable.

4. Verify that locations shown on Operators Work Station are schematically correct.

5. Identification/number

6. Location

7. Service

8. Manufacturer

9. Temperature, test reading and actual

10. Pressure, test reading and actual

11. **A**ir composition, parts per million, test reading and actual. Test and adjust at normal ambient and alarm conditions.

T. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

## 3.13 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 water flow of each device.
b. Verify that balancing devices are marked with final balance position.
c. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection by TAB Agency is complete and documentation verifies that testing and balancing are complete and accurately documented in the report, request that a final inspection be made, giving at minimum 7 calendar days' notice. Deliver copies of Draft Final Report to Engineer and Commissioning Authority with final inspection request.

a. Engineer may elect to postpone final inspection upon delivery of written notice to TAB Agency that significant portions of the required TAB results are missing from draft report. If inspection is postponed, TAB Agency shall promptly return to site and provide missing TAB Work, then submit a revised draft and request the Final Inspection again.

2. The TAB Agency and Contractor's qualified technicians are to provide access, tools, and measurements during the inspection in the presence of the TAB Agency Supervisor and the Commissioning Authority.

3. Commissioning Authority will randomly select measurements, documented in the report or as required by contract, to be rechecked. Rechecking will 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." If recheck calls for a measurement that is required but cannot be found in the draft report, the missing measurement will be noted as "MISSING".

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB Work will be considered defective and rejected. If the number of "MISSING" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB Work will be considered defective and rejected.

C. If TAB Work is considered defective and rejected, 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. Pay all costs associated with second inspection including Commissioning Authority's reasonable additional fees.

2. If the second final inspection also fails, Owner may require additional inspection similar to second inspection or may contract the services of another TAB agency to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB Agency's final payment.

D. Prepare test and inspection reports.

## 3.14 ADDITIONAL TESTS

A. Re-check and adjust systems approximately 6 months after final acceptance and submit report:

1. Measure the total flow rate of each of the systems originally covered by this section.

2. For each of the systems that no longer operate at design flow measure the flow at each of the terminals of that system.

3. Measure the flow at any terminals included in the original balancing, reported by the Owner or Architect to have continued or new problems.

4. Adjust system changes back to the design values if possible, and submit reports in writing to the Architect, Contractor, and Owner, noting any changes and/or complaints, and offering an interpretation of the cause and significance of the problems.

5. If the design air temperature criteria as specified cannot be satisfied upon initial balancing, perform this six month stability check at a time when it can be, and repeat water system balancing and chiller / heat exchanger performance testing using air temperature at the design conditions.

END OF SECTION 23 05 93

# SECTION 23 07 00 – HVAC INSULATION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes materials and installation requirements for mechanical component insulation and related accessories.

1. Insulation Materials:

a. Calcium silicate.
b. Cellular glass.
c. Flexible elastomeric.
d. Mineral fiber.
e. Phenolic.
f. Polyisocyanurate.
g. Polyolefin.
h. Polystyrene.

2. Insulation Accessories:

a. Insulating cements.
b. Adhesives.
c. Mastics.
d. Lagging adhesives.
e. Sealants.
f. Factory-applied jackets.
g. Field-applied fabric-reinforcing mesh.
h. Field-applied cloths.
i. Field-applied jackets.
j. Tapes.
k. Securements.
l. Corner angles.
m. Insulation protection systems

### 1.3 DEFINITIONS

A. “Concealed”: Work within or behind various construction elements, or in crawl spaces or trenches, that is not exposed to view when Project has been completed. (Areas above ceilings, including above Auditorium or Large Group Instruction partially open “cloud” ceilings and chases are considered a concealed location.)

B. “Exposed”: Anything exposed to view when project has been completed.

## 1.4 SUBMITTALS

A. Comply with requirements of SECTION 01 33 00 – Submittal Procedures and as modified below.

B. Provide all submittals required by this Section concurrently.

C. Product Data

1. Submit complete manufacturer's product information for each type of insulation and accessory specified in this section demonstrating compliance with specified requirements and including:

   a. Thermal and vapor transmission performance.
   b. MSDS information.
   c. Flame spread / smoke developed data.
   d. Manufacturer's recommended installation methods.

D. Submit insulation schedule indicating each required service with type of insulation, thickness and R value, covering method, finishes, and any applicable notes.

E. Quality Control Submittals

1. Qualifications Certification: Submit written certification of installers signed by applicable certification agency and/or manufacturer (where applicable) indicating compliance with "Installer Qualifications" requirements specified below in "Quality Assurance" article.

2. Installer Experience Listing: Submit list of completed projects using products proposed for this Project, including Owner contact information for each project, demonstrating compliance with applicable "Qualifications" requirements specified below in "Quality Assurance" article.

F. Contract Closeout Submittals: Comply with requirements of DIVISION 1 sections on closeout, including submission of maintenance instructions as item in "Operating and Maintenance Data" manual described there.

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: Provide insulation system installation by qualified Installers who are trained in installation of each proposed insulation material and product with at least one of the following qualifications:

1. Have successfully completed a mechanical insulation apprenticeship program by the Department of Labor, Bureau of Apprenticeship and Training,
2. Have successfully completed an ASHRAE / NIA 8 hour Mechanical Insulation Training course or equal, or
3. Have five years documented experience as a mechanical insulation specialist with references attesting to successful completion of at least three comparable projects.

B. Condensation Resistance: Provide insulation and vapor barrier systems complete as required to eliminate condensation under any normal operating conditions from surfaces of all cooling equipment and components provided or modified as a part of this contract Work, unless those surfaces are designed to remove moisture by condensation from process air, and to contain and drain the condensate.

C. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, 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.

D. Mockups: Before installing insulation in general, install example mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Install mockups in the location indicated or, if not indicated, in general in conveniently accessed locations in mechanical spaces where insulation will remain exposed for continued review. Coordinate specific locations with CM and Architect. Use materials indicated for the completed Work.

1. Piping Mockups (Exterior Piping Only):

a. One 10-foot section of straight pipe for exterior application.
b. One each of a 90-degree welded elbow for exterior application.
c. One NPS 2-1/2 inch or larger valve for exterior application.
d. Four support hangers including hanger shield and insert for exterior application.

## 1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Components."

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.

## 1.7 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.

## 1.8 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.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. For convenience, details and specifications have been based on products by the following manufacturers:

1. Armstrong; Lancaster, Pennsylvania
2. Benjamin Foster
3. CertainTeed; Valley Forge, Pennsylvania
4. Fit Tight Covers, Inc.
5. Johns Manville; Defiance, Ohio
6. Kingspan Tarec
7. Knauf; North Carolina
8. No Sweat Valve Wraps, Inc.
9. Owens-Corning; Toledo, Ohio
10. Polyguard Products Inc., Ennis, Texas
11. Thermaxx, LLC.
12. Or Approved Equal.

## 2.2 MATERIALS

A. Pipe and Fitting Insulation: Provide pipe insulation in compliance with ASTM C 585 Dimensional Standards.

1. Insulation Thickness:

a. Pipe and fitting insulation thicknesses specified assume an insulation conductivity (k) value of 0.27 btu•in/hr•ft2•ºF. For pipe and fitting insulation with conductivity other than 0.27 btu•in/hr•ft2•ºF, insulation must be thicker for higher conductivity and may be thinner for lower conductivity as required to achieve same or higher R value. Adjust insulation thickness from that specified in accordance with the following formula:

$T = r[(1+t/r)K/k-1]$ where:

1) T = Adjusted insulation thickness, inches
2) r = Actual pipe outside radius, inches.
3) t = Insulation thickness specified, inches.
4) K = actual insulation conductivity, btu•in/hr•ft2•ºF.
5) k = specified conductivity, 0.27 btu•in/hr•ft2•ºF.

b. Hydronic Piping for Heating or Heating / Cooling (dual temp):

1) Pipe sizes ½ inch through 1-¼ inches ..... 1-1/2 inch
2) Pipe sizes 1-½ inches and larger ..... 2 inches

c. Condensate Drain Piping

1) All pipe sizes ..... ½ inch

d. Runout piping in restricted spaces where it is not possible to provide the specified thickness may use reduced thickness insulation as required by space restriction.

2. Interior Above Grade Hydronic Piping Insulation:

a. ASTM C547, cylindrically molded preformed rigid half pipe shell forms, factory one-piece "hinged" construction.

1) Rigid pipe or tube insulation may be of mineral wool, fiberglass, closed cell glass, formed polyisocyanurate, formed phenolic, or extruded polystyrene (chilled service only).

2) Thermal Conductivity ("k"): Measured in accordance with ASTM C 335. For k values greater than 0.27, include calculations and compliant increased thickness proposed. For k values equal or less than 0.27, provide specified insulation thickness or calculations justifying thinner insulation.

3) Jacket: All Purpose (AP) vapor barrier jacket with:

a) White kraft paper outer surface bonded to aluminum foil, reinforced with fiberglass yarn, permanently treated for fire and smoke safety and to prevent corrosion of foil.

b) Self sealing pressure sensitive lap.

c) Water Vapor Permeance: ASTM E96, Procedure A, 0.02 perm maximum.

d) Puncture resistance: ASTM D781, 85 scale units minimum

e) Burst resistance: ASTM D774, 100psi minimum.

f) Similar to "150TL facing" as used in "AP T Plus Jacket" and tape by Johns Manville, or equal.

3. Exterior Above Grade Hydronic Insulation:

a. ASTM C547, cylindrically molded preformed rigid half pipe shell forms, factory one-piece "hinged" construction.

1) Rigid pipe or tube insulation may be of closed cell glass, formed polyisocyanurate, formed phenolic, or extruded polystyrene (chilled service only).

2) Thermal Conductivity ("k"): Measured in accordance with ASTM C 335. For k values greater than 0.27, include calculations and compliant increased thickness proposed. For k values equal or less than 0.27, provide specified insulation thickness or calculations justifying thinner insulation.

3) Exterior Pipe Insulation Protective Jacket specified below.

4. Fitting and Valve Insulation: Precut fiberglass blanket to match thickness, appearance and insulation value of adjacent pipe insulation; similar to "Hi Lo Temp Fiber Glass Insulation Insert" by Johns Manville, with fitted protective jacket specified for the installation.

B. Pipe and Fitting Protective Jackets:

1. Intended for permanent installation on non-serviceable components only.

2. Interior Pipe and Fitting Insulation Protective Jacket:

a. Plastic: High-impact, UV resistant polyvinyl chloride, white, paintable, covering designed to fit over AP jacketed insulated piping systems, molded to fit various sizes of fittings and piping as required; similar to "Zeston 2000 or Zeston 300 PVC Jacketing" by Johns Manville.

1) 20 mil thickness: Fittings and valves in interior applications eight feet above finished floor and higher.
2) 30 mil thickness: Fittings, valves, and straight pipe in interior applications lower than eight feet above finished floor.

b. Aluminum: Circumferentially corrugated 20mil thick or embossed 24 mil thick, with approved moisture barrier, with matching preformed fitting covers by same manufacturer. Similar to Corrolon by Childers.

3. Exterior Pipe and Fitting Insulation Protective Jacket: Modified bituminous, aluminum skinned, peal and stick membrane, similar to Polyguard "Alumaguard 60", with the following properties:

a. Minimum 60 mils thick
b. Permeance less than 0.01 Perms
c. Puncture resistance per ASTM E154 >40lbs.
d. Overlap bond peal adhesion per ASTM D1000 never less than 11lb/in.
e. UV stabilized.
f. Self healing when punctured.

C. Valve Covers, Serviceable Hydronic Component Insulation Jackets:

1. Control Valves, balance valves, etc., and other similar piping components needing periodic service, maintenance or adjustment - provide easily removable insulation jacket requiring no special tools for installation or removal / replacement:

a. Factory fabricated removable and reusable cover similar to products by No Sweat Valve Wraps, Inc., or approved equal.

b. Size so outer jacket overlaps adjoining sections of pipe insulation.

c. Flame and smoke spread 25/50 per ASTM E-84 or less.

d. Maximum k- factor .26 or matching surrounding insulation, using fiberglass blanket.

e. Outer jacket made of material equal to DuPont Tychem® QC (polyethylene coated Tyvek) , overlapping and completely covering the insulation with seams joined by integral elastic banding and tabs made from hook and loop fasteners (Velcro).

f. Butt ends and stem penetrations have sewn-in-place elastic. On cooling service, provide PSA backed closed cell foam gasket material adhered to stem penetration or surrounding insulation jacket between substrate and elastic jacket closure, as required insuring a complete vapor seal.

D. Duct Insulation

1. Provide insulation thickness on ducts, plenums, and equipment equal to height of flanges, but not less than thickness required to achieve duct insulation R values specified herein:

a. R=6 deg. F-sq. ft.-h/Btu-in:

1) All interior HVAC duct where insulation is required, unless otherwise noted elsewhere.

b. R=12 deg. F-sq. ft.-h/Btu-in

1) Interior outside air intake duct

c. R=12 deg. F-sq. ft.-h/Btu-in:

1) Exterior Duct with no transverse dimension above 48 inches (R=10 minimum, not average)

d. R=20 deg. F-sq. ft.-h/Btu-in:

1) Exterior Duct with any transverse dimension above 48 inches (R=20 minimum, not average)

e. Insulate to Special R values, as specifically noted elsewhere:

1) Boiler breeching, high temperature duct, fire rated duct

2. Rigid Board: 3 PCF minimum density glass fiber board (6PCF when exposed in mechanical or utility spaces) or phenolic, with factory-applied AP vapor barrier; similar to “800 series Spin-Glas” and “AP” facing by Johns Manville, or Kingspan KoolDuct.

3. Semi-Flexible: 2.5 PCF minimum density continuous glass fiber oriented strand sheets, with factory-applied AP vapor barrier. Strand orientation such that material has comparable rigidity to board type insulation above in one direction and comparable compressive strength, but is flexible enough in the other direction to wrap curved surfaces at a factory recommended minimum bend radius of 3T where T is the material thickness. Similar to "CrimpWrap" by CertainTeed.

4. Flexible: Glass fiber blanket, 3/4 PCF minimum density, with factory-applied, flame-resistant, FSK jacket; all joints taped; similar to Owens Corning "Fiberglas All Service Duct Wrap".

5. Acoustical / Thermal Duct Lining:

    a. Increase sheet metal size as required to provide free area shown on drawings

    b. 1-inch thick minimum for sound lining or as otherwise noted. Where used together with external duct insulation, the combined R value must be at least that specified for the service. Where used in lieu of other thermal insulation, provide with rated R-value at least that specified for duct application.

        1) R6 duct service = 1.5 inches thick minimum
        2) R12 duct service = 3 inches thick minimum.

    c. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature (R value equals 4.2 per inch minimum).

    d. Surface exposed to air stream and factory edges bonded then coated with a fire, bacterial, fungal and abrasion resistant coating; rated for velocities up to 4000 fpm.

    e. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723 or ASTM E 84 as applicable, meets requirements of NFPA 90A; certified by an NRTL.

    f. Materials:

        1) Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

        2) Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

    g. Liner Adhesive: As recommended by insulation manufacturer, low VOC, complying with NFPA 90A, NFPA 90B, and with ASTM C 916 as applicable.

6. Exterior Duct Insulation: Rigid closed-cell extruded polystyrene or phenolic board with integral high density skin, foil or poly faced as recommended by insulation covering manufacturer, tongue and groove along long edges; complying with and exceeding requirements of ASTM C 578 for Type IV insulation, with the following properties:

    a. Density: 1.6 pcf minimum.
    b. Thermal resistance (R) at 75 deg. for 1-inch thickness: 5 nominal.
    c. Compressive resistance at 10 percent deformation or yield: 25.0 psi minimum.
    d. Tapered thickness as required to provide ¼" to the foot slope for water shedding.
    e. Flame spread (ASTM E84): less than 75.
    f. Fuel contributed (ASTM E 84): less than 100.
    g. UL listed.

E. Ductwork Insulation Protective Jackets:

1. All Purpose (AP) Vapor Barrier for Duct Insulation: White kraft paper outer surface bonded to aluminum foil and reinforced with fiberglass yarn, permanently treated for fire and smoke safety and to prevent corrosion of foil.

    a. Water Vapor Permeance: ASTM E96, Procedure A, 0.02 perm maximum.
    b. Puncture resistance: ASTM D781, 85 scale units minimum
    c. Burst resistance: ASTM D774, 100psi minimum.
    d. Similar to "150TL facing" as used in "AP T Plus Jacket" and tape by Johns Manville, or equal.

2. Foil-Skrim-Kraft (FSK) Vapor Barrier for Duct Insulation: Foil faced outer surface bonded to kraft paper backing and reinforced with fiberglass yarn, permanently treated for fire and smoke safety and to prevent corrosion of foil.

    a. Water Vapor Permeance: ASTM E96, Procedure A, 0.02 perm maximum.
    b. Similar to "FSK Jacket" and tape by Johns Manville, or equal.

3. Exterior Duct Insulation Covering:

    a. Modified bituminous, aluminum skinned, peal and stick membrane, similar to Polyguard "Alumaguard 60", with the following properties:

        1) Minimum 60 mils thick
        2) Permeance less than 0.01 Perms
        3) Puncture resistance per ASTM E154 >40lbs.
        4) Overlap bond peal adhesion per ASTM D1000 never less than 11lb/in.
        5) UV stabilized.
        6) Self healing when punctured.

    b. EPDM membrane as specified in Division 07 section 07 53 23 – EPDM Roofing.

F. Insulation Accessories:

1. Mechanical Pin Fasteners: Provide welded or adhered pins of length based on manufacturer's recommendations for insulation density and thickness, securely holding insulation with insulation manufacturer's recommended compression. Mechanical Pin Fastener types include:

   a. Stud style welded pins minimum 12 gauge diameter with matching push-on washers. Welded on with capacitor discharge type pin welder with no burn through or undercutting. Welded on prior to insulation application allowing for inspection prior to insulating.

   b. Cup head style welded minimum 12 gauge diameter with integral washers. Welded on with capacitor discharge type pin welder with no burn through or undercutting. Welded on after insulation application dis-allowing inspection of pin welds without insulation removal. Not permitted for any Class A or tighter duct, not permitted for any fire rated duct insulation application.

   c. Adhered style with perforated metal back plate (minimum 4 square inches surface area) welded to 12 gauge pins with matching push washers, bonded with full coverage of manufacturer's recommended adhesive. Not permitted for any fire rated duct insulation application.

   d. Not permitted: PSA backed "peal and stick" pins, sheet metal fastening screws, or any other penetration of duct by fasteners.

2. Insulation Securement Bands: For larger cylindrical surfaces and fire rated duct insulation, tension securement bands may be used to supplement or replace mechanical pin fasteners. Provide bands of material compatible with insulation and system being insulated, minimum ½ inch wide and as required to avoid compressing insulation at required securement tension (3/4 inch minimum for diameters over 36 inches), 24 gage thick or thicker. End buckles of similar material. Wrapping or securing with wires not permitted.

3. Insulation Covering Canvas: 8 oz., 100 percent cotton, with flame spread 10 and smoke developed 0 ratings; similar to "Thermocanvas" by Fattal, Chicago, Illinois.

4. Insulation Tapes: Provide insulation manufacturers' recommended and matching tapes, matching characteristics of exterior jacket of insulation, in widths as required and as specified below to seal all gaps and reinforce vulnerable areas in vapor barrier. Provide tapes with peel off protective coating covering high performance acrylic adhesive unless manufacturer documents superior performance of alternative recommendation.

5. Insulation Adhesives and Mastics: Provide insulation manufacturers' recommended and matching adhesives and mastics, as required and as specified below to seal all gaps and reinforce vulnerable areas in vapor barrier. Provide with water based and low VOC formulations unless manufacturer documents superior performance of alternative recommendation and performance deficiencies of water based low VOC products.

6. Corrosion Inhibition Coating:

   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) Polyguard Brand, ReactiveGel™ RG-2400 series of coatings and accessories.

   b. Materials shall be compatible with insulation materials, jackets, substrates, and conditions of service. Provide product formulation specifically designed for the conditions of service.

   c. Product is a field applied gel chemical surface conversion compound utilizing reactive mineralization technology, creating a corrosion resistant mineral barrier 50-200 angstroms deep into the metal surface which increases in thickness as time passes.

   d. Viscosity: Brookfield method; 200,000-300,000 cps

   e. Specific Gravity: Gravimetric; 0.98-1.08

   f. Application: Spray, rag, brush, roll, glove.

   g. Corrosion test performance, thickness .025":

      1) 1000 hours Accelerated Weathering per ASTM B117 - pass with no corrosion.
      2) ASTM G-23 – pass with no corrosion.

   h. Service Temperature Range: Minus 40 to plus 350 deg F. depending on formulation.

   i. Color: Blue.

   j. V.O.C.: EPA Method

## 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.
B. Verify that systems and equipment to be insulated have been tested and are free of defects.
C. Verify that surfaces to be insulated are clean and dry.
D. Proceed with installation only after unsatisfactory conditions have been corrected.
E. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion inhibition coating to surfaces to be insulated as follows:

1. All non-galvanized ferrous components with a service temperature below ambient (chilled water and chilled water/glycol systems): Coat with one full coverage coat of specified corrosion inhibition coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

## 3.3 INSTALLATION

A. General:

1. Provide thermal and acoustical insulation for components shown on the Drawings as specified in this Section for the following:

a. All heating and air conditioning systems piping including fittings, valves, and accessories.

1) Include removal of existing insulation and replacement insulation as specified for existing piping where called for on the drawings or where existing insulation is damaged as a result of contract work.

2) Include re-insulation where insulation is removed as a part of the abatement work, and not otherwise replaced. Refer to abatement drawings for quantities.

b. All heating and air conditioning ductwork unless noted otherwise.

1) All heating and air conditioning ductwork labeled as exposed shall not be insulated unless noted otherwise.
2) All heating and air conditioning ductwork within a Mechanical Room, Boiler Room, Fan Room, etc., shall be insulated whether exposed or not.

c. All outside air ductwork extending from exterior wall or roof to the equipment which it serves.

d. Exhaust, return, and relief air ductwork not passing through air to air energy recovery devices prior to exiting the building: extending from exterior wall or roof 15 feet into the building envelope in all directions of duct branch take-offs.

e. Exhaust, return, and relief air ductwork that does pass through air to air energy recovery devices prior to exiting the system: insulate complete as described below.

f. All cooling condensate drain lines.

2. Comply with manufacturer's installation instructions and recommendations.

3. Do not begin mechanical insulation until permission is granted to begin mechanical insulation installation, hydronic systems have proved drip free under pressure, duct systems have passed required duct leakage requirements and testing, indoor work areas are weather tight, and outdoor work areas are at appropriate ambient conditions.

4. Below ambient temperature applications:

a. Provide corrosion inhibition coating as specified above.
b. Apply vapor barrier mastic and sealant to all open ends, joints, seams, breaks, and punctures in insulation.

5. Do not use any insulation support system which causes compression of insulation, localized or widespread, to less than 75% of the rated nominal thickness. Wires wrapped around rectangular duct insulation are not permitted as insulation support.

6. Provide for durable and repeated service access as part of insulation system.

a. Do not permanently cover inspection stampings, hand holes, manholes, plugged outlets, or similar features on equipment – provide removable labeled insulated access port with beveled and sealed insulation plug, gasketed if vapor barrier is needed, durably fabricated for repeated access.

b. Provide removable insulated boxes as specified for Control valves, and other HVAC components needing periodic maintenance or adjustment.

7. Install thermal mechanical insulation as follows:

a. Only on clean, dry surfaces and after piping and ductwork has been tested and found to be tight.
b. Continuously through wall or ceiling openings and sleeves.
c. On cold surfaces with continuous unbroken vapor seal.
d. Insulate ducts and pipes individually.

8. Where more than one layer of insulation is required to achieve specified thickness or R value, apply thinner layer first, and stagger joints between insulation layers at least 3 inches.

B. Pipe Insulation

1. Comply with manufacturer's installation instructions and recommendations. Install only when ambient temperatures are within range recommended by manufacturer. STAPLES NOT PERMITTED.

2. Provide high impact plastic wrapper on all exposed, insulated piping from finished floor to 8 ft. above finished floor.

3. Interior Pipe and Fitting Insulation: Install on all heating, cooling, and condensate piping. Seal with factory applied pressure-sealing adhesive strip on the longitudinal lap. Seal butt joints with pressure-sealing adhesive strip at least 2 inches wide. Install valve and fitting covers in all locations.

4. Insulation at Pipe Support: Refer to SECTION 23 05 29 - Hangers and Supports for material specifications of insulated piping support assembly and pipe support insulation. Complete insulation installation for the applicable pipe support insulation type to be used.

   a. Type “B” Pipe Support Insulation:

      1) Install pipe support insulation at hanger and support locations in conformance with manufacturer’s recommendations and as indicated on Drawings.

      2) Remove a section of insulation from pipe insulation and replace this section with heavy density molded fiberglass blocks without breaking vapor barrier wrap.

   b. Type “C” Pipe Support Insulation:

      1) Provide butt connection to high-density insulation sections at pipe hangers as specified in Section 23 05 29 - Hangers and Supports.

      2) Provide insulation with vapor barrier on upper half of insulated piping support assembly.

      3) Apply wet coat of vapor barrier lap cement on butt joints and finish coat of vapor barrier mastic.

      4) Tape edge of insulation section edge and insulation with white, pressure-sensitive PVC tape with tape extending over adjacent pipe insulation by at least 2 inches.

C. Ductwork Insulation: Provide external thermal insulation on ducts as specified or indicated on Drawings; external thermal insulation not required where ducts are shown or specified with internal acoustical insulation. Insulate and seal around duct dampers, damper motors, thermometers, instruments, access doors, and similar component as required without restricting operation or function. Insulate all ducts in all concealed spaces.

   1. Use flexible type insulation on concealed ductwork with widths or diameters of 18 inches or less only. Insulate all other ductwork requiring insulation with rigid board type, semi-flexible type, or other type as required by drawings and specifications.

   2. Duct Insulation Mechanical Fasteners: Provide mechanical fasteners for all duct surfaces over 12” wide. For duct surfaces 18’” wide and less, provide single row of fasteners down duct centerline. For duct surfaces over 18” wide, install minimum of 2 rows per side, applied on maximum 18" centers, starting within 3" of any edge.

a. Pins with the point facing out accepting push washers: clip points close to washers and cover with vapor barrier adhesive and tape. Not permitted on mechanical room duct unless covered by puncture resistant protective wrapper.

3. Duct Insulation Tape: Apply only to clean dry dust free surfaces as recommended by tape manufacturer and as required for durable adhesion.

   a. Pealing tape, loose insulation, or otherwise broken vapor barrier subject to repeated recall.

4. Rigid Board Type Insulation Installation: Install board with all corners mitered or rabbeted; no butt joints allowed. Secure insulation with mechanical fasteners. Apply corner reinforcement angles (beads) on all corners for exposed ductwork (including in mechanical or storage spaces), with edge tape over beads. Seal all breaks and joints in vapor barrier with 3 to 5 inches wide insulation tape (minimum 1.5" tape past break all around).

5. Semi-flexible Type: Install similar to rigid board type, on round duct, curved elbows, etc.. Wrap curved and round surfaces taught, provide circumference tape band maximum two feet on center (butt joints and center of four foot roll stock).

6. Flexible Type Insulation Installation: Make all joints and seams with 2-inch lap of vapor barrier cemented with Benjamin Foster "BF85-20". Apply Benjamin Foster "BF-20" adhesive to ducts in 6-inch brush widths at 1 ft. intervals and at each facing edge. Tape all adhered with Benjamin Foster "BF-20". Tape seal all seams, breaks, and joints in vapor barrier, then continuously coat all tape with manufacturer's recommended vapor barrier adhesive

7. Acoustical Duct Lining: Install on low velocity ductwork as noted on Drawings, adhering to sheet metal duct with 100 percent coverage of adhesive meeting the requirements of ASTM C 916, and additionally securing with mechanical fasteners as noted above but on 12-inch centers maximum in the transverse direction. Seal all edges, transverse joints and fastener penetrations with approved mastic. Protect all exposed edges with metal nosing causing no greater than 10% compression of the liner.

8. Exterior Duct Work Insulation: Install insulation and covering in strict compliance with manufacturer's printed instructions and recommendations and as follows:

   a. Mechanically fasten insulation to duct.

   b. Slope top insulation a minimum ¼" per foot for positive drainage using tapered thickness panels, not shims with air gaps below.

   c. Tape joints and ruptures in facing, using adhesive tape of type recommended by insulation manufacturer, and seal each continuous area of insulation to surrounding construction ensuring vapor tight installation.

   d. Seal and protect exterior duct work insulation with Exterior Duct Insulation Covering, making all joints and terminations watertight with any and all special details as required by application.

e. Mechanically support bottom of duct Exterior Duct Insulation Covering on all exterior duct 24 inches wide and wider such that there is no unsupported dimension over 30 inches. Provide transverse and if required longitudinal strut system compressing Exterior Duct Insulation Covering against bottom of duct. Refer to Section 23 05 29 – Hangers and Supports for HVAC Components, for details of corrosion resistance and construction of insulation support system.

f. Provide for air pressure bleed ports in the bottom of insulation system of exterior positive pressure duct as required to bleed off duct leakage without pressurizing insulation system. Typical bleed port shall be similar to ¼" OD nylon tubing penetrating bottom of insulation full thickness of insulation, extending ½ inch below insulation cover, cut off at 45 degrees both ends, and sealed to insulation and covering with appropriate caulk. On vertical duct, slope down for drainage. Provide one bleed port for every 10 linear feet of exterior duct.

1) Test and eliminate duct leakage before applying insulation system. If additional bleed ports are needed to prevent insulation covering from bulging out between supports due to internal pressure, remove insulation and reseal duct to control leakage.

END OF SECTION 23 07 00

# SECTION 23 08 00 - COMMISSIONING OF HVAC

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

1. See especially Section 01 08 00 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.

### 1.2 SUMMARY

A. Section includes commissioning process requirements for the following Building Mechanical Systems, which are described in more detail in the technical specifications of Division 23.

1. Distribution systems, including supply and return air distribution (heating and cooling) systems, hot water distribution systems, changeover distribution systems (hot and chilled water/glycol), exhaust systems air-handling units.

2. Terminal and packaged units, including unit ventilators, fan-coil units, and finned-tube radiation.

3. Vibration, sound, and movement control systems, including vibration isolation devices, sound attenuation, and seismic restraints.

4. Energy Management and Control System.

5. Systems testing, adjusting, and balancing verification, including all of the above mentioned systems.

### 1.3 DEFINITIONS

A. BAS: Building automation system, also known as Energy Management and Control System (EMCS).

B. Building Mechanical Systems: All Systems, Subsystems, Equipment, and Components of the building systems traditionally known as Heating, Ventilating, Air Conditioning, Refrigeration, Plumbing, and Electrical Works.

C. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

D. CxA: Commissioning Authority –The Owner or a third party commissioning agent designated by the Owner.

E. DDC: Direct digital controls, a part of the BAS.

F. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

G. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

H. TAB: Testing, adjusting, and balancing.

## 1.4 SUBMITTALS

A. Qualification Data: For BAS and HVAC&R Testing Technician.

B. Construction Checklists: Provide construction pre-functional test checklists filled out by qualified technician for all equipment to be commissioned on this project, including but not limited to all :

1. Vibration, Sound, and Movement.
2. BAS.
3. Hydronic HVAC water piping and accessories.
4. Refrigerant piping.
5. Metal ducts and accessories.
6. Fans.
7. Energy Recovery Air-handling Systems.

C. Certificates of readiness and completion of installation.

D. Test and inspection reports and certificates.

E. Corrective action documents.

F. Instrumentation Calibration Information

G. Functional Performance Test Procedures

## 1.5 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level with knowledge of BAS, HVAC&R, electrical concepts, and building operations.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. International Society of Automation (ISA) Certified Control Systems Technician (CCST) Level I.

B. HVAC&R Testing Technician Qualifications: Technicians to perform HVAC&R construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level. Vocational School four-year program graduate or an Associates degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC&R systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC&R equipment, assemblies, and systems.

2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.

3. One of the following:

    a. National Environmental Balancing Bureau (NEBB) Certified Testing, Adjusting, and Balancing Technician.
    b. Associated Air Balance Council (AABC) Certified Test and Balance Technician.
    c. Owner retains the right to waive NEBB or AABC Certification.

C. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform HVAC&R commissioning work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:

    a. Equipment/instrument identification number.
    b. Planned commissioning application or use.
    c. Manufacturer, make, model, and serial number.
    d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.

2. Test equipment and instrumentation shall meet the following criteria:

    a. Capable of testing and measuring performance within the specified acceptance criteria.
    b. Be calibrated at the manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
    c. Be maintained in good repair and operating condition throughout the duration of use on this Project.
    d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the commissioning process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:

a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:

1) Instrument or tool identification number.
2) Equipment schedule designation of equipment for which the instrument or tool is required.
3) Manufacturer, make, model, and serial number.
4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

b. Include a separate list of proprietary test instrumentation and tools in the operation and maintenance manuals.

c. HVAC&R proprietary test instrumentation and tools become the property of Owner at the time of Substantial Completion.

## 1.6 CONTRACTOR'S RESPONSIBILITIES

A. Provide mechanical work in accordance with contract document requirements.

B. Perform commissioning tests including Materials Checks, Installation Checks, Start-up Checks, Startups, and Functional Testing, all at the direction of the CxA.

C. Attend construction phase controls coordination meetings.

D. Attend and participate in TAB review and coordination meetings

E. Attend and participate in commissioning meetings.

F. Participate in Building Mechanical Systems maintenance orientation and inspection as directed by the CxA.

G. Prepare Construction / Prefunctional Checklists and Functional Performance Test procedures and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms for review and approval.

H. Submit documentation required for Commissioning work. At minimum, include: Detailed Start-up procedures, Full sequences of operation, Operating and Maintenance data, Performance data, checkout sheet forms used by factory or manufacturer’s field technicians, Functional Performance Test Procedures, Control Drawings, and details of Owner-Contracted tests.

I. Review and approve other relative documentation for impact on Functional Performance Tests of the systems:

1. Shop Drawings and product submittal data related to systems or equipment to be commissioned. Review and incorporate comments from the CxA.

2. Incorporate manufacturer’s Start-up procedures with Prefunctional checklists.

3. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the Functional Performance Testing.

4. Complete equipment Construction / Prefunctional Checklists, Start-up certification forms, and the manufacturer's field or factory performance and Start-up test documentation: review the documentation prior to commencing with the scheduled Functional Performance Tests.

5. Final Testing Reports: Contractor or Subcontractor performing the test will review the documentation prior to commencing with the scheduled Functional Performance Tests.

6. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the Functional Performance Tests, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

J. Provide information requested by the CxA for final commissioning documentation.

K. Schedule work so that required installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.

L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

M. Inspect, check and confirm in writing the proper installation and performance of all Work.

N. Provide technicians to assist during system verification and functional performance testing as required by the CxA

## 1.7 CxA'S AUTHORITY

A. Directing Commissioning.

B. Assign Commissioning Agent for various commissioning tasks to stand in for the CxA.

C. Edit and approve project-specific construction checklists and commissioning process test procedures for actual Building Mechanical Systems, assemblies, equipment, and components to be provided as part of the construction contract.

D. Verify Testing, Adjusting, and Balancing of Work are complete.

## 1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Building Mechanical Systems to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that Building Mechanical Systems and associated controls are ready for testing.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that Building Mechanical Systems have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that Building Mechanical Systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that Contractor portions of testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing report discrepancies have been corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Provide (Furnish and Install) measuring instruments and logging devices to record test data as directed by the CxA.

3.2 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning tests at the direction of the CxA.

B. Scope of Building Mechanical Systems testing includes entire HVAC&R installation. Testing includes measuring capacities and effectiveness of operational and control functions, accuracy and precision of sensing equipment, and other functional parameters as required, demonstrating that systems are performing as specified and intended. Commissioning testing includes verification of up to 30 percent of the control points, Testing and Balancing data, and other system requirements indicated in the individual technical sections, and on the drawings and schedules of these contract documents. Parameters not otherwise specified to be tested, as required to adequately demonstrate system performance, may constitute up to 10 percent of the 30 percent (3 percent of total).

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Building Mechanical Systems Contractors and their Subcontractors, especially the Testing, Adjusting, and Balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor, shall prepare detailed testing plans, procedures, and checklists for Building Mechanical Systems based on the actual installed equipment and the contract documents.

E. Perform tests using design conditions whenever possible.

1. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

2. The CxA may direct that set points be altered when simulating conditions is not practical.

3. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

F. If tests cannot be completed because of a deficiency outside the scope of the Building Mechanical System, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests. If deficiencies cannot be resolved, refine tests as required to adequately test Building Mechanical Systems within the constraints of the deficiency.

G. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

## 3.3 TESTING, ADJUSTING, AND BALANCING (TAB) VERIFICATION

A. Prior to performance of TAB Work, provide copies of approved sample report forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of TAB Work, and provide access for the CxA to witness Testing, Adjusting, and Balancing Work.

C. Subsequent to approval of formal TAB report, TAB Work will be subject to field verification. Provide technicians, instrumentation, and tools to verify testing and balancing of Building Mechanical Systems at the direction of the CxA. Roughly 10% of required TAB data points identified in TAB specification will be selected for subsequent field verification.

1. The CxA will notify TAB Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified..

2. The TAB Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

## 3.4 SPECIFIC COMPONENT AND SYSTEM COMMISSIONING TESTS

A. Air Distribution Systems

1. TAB Air Flow Verification:

a. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

b. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

c. Scope: HVAC&R air systems and hydronic piping systems.

d. Purpose: Differential flow relationships intended to maintain air pressurization differentials between the various areas of Project.

e. Conditions of the Test:

1) Commissioning Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

2) Systems operating in full heating mode with minimum outside-air volume.

3) Systems operating in full cooling mode with minimum outside-air volume.

4) For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

f. Acceptance Criteria:

1) Under all conditions, rechecked measurements comply with "Inspections" Article in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

2) Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.

3) Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

B. Air System Energy Recovery Systems

1. Energy Recovery Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Section “Testing, Adjusting, and Balancing for HVAC”. Provide submittals, test data, inspector record, and heat exchanger certification to the CxA. Heat exchanger shall exchange the energy flows scheduled with no greater pressure drop or approach temperatures than scheduled.

C. Exhaust Systems

1. Exhaust Fan Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Section “Testing, Adjusting, and Balancing for HVAC”. Provide submittals, test data, inspector record, and exhaust fan performance certification to the CxA. Exhaust fans shall be equipped with all accessories as specified and scheduled and shall be demonstrated to operate on the approved fan curve with no greater than the approved power requirements.

D. Air-Handling Systems

1. Air-Handler Mixed-Air Control:

a. Prerequisites: Installation verification of the following:

1) Minimum Position Input Device: DDC system time schedule.

2) Output Device: DDC system analog output to modulating damper actuator(s).

3) Heating Reset Input Device: DDC system software.

4) Supply-Air Temperature Input Device: Electronic temperature sensor.

5) Display the following at the operator's workstation:

a) Mixed-air-temperature indication.
b) Mixed-air-temperature set point.
c) Mixed-air damper position.

b. Scope: Air handler with mixed-air control and associated controls.

c. Purpose:

1) Occupied time control.
2) Minimum damper position control.
3) Heating reset control.
4) Supply-air temperature control.
5) Cooling reset control.
6) Unoccupied time control.

d. Conditions of the Test:

1) Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.

2) Minimum Damper Position Control: Command system to mode in which minimum damper position is required.

3) Heating Reset Control: Create a call for heating.

4) Supply-Air Temperature Control: Override supply-air temperature set point to a value 2.0 deg F above current supply-air temperature.

5) Unoccupied Time Control: Advance to unoccupied schedule time.

6) Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at hourly intervals. Submit trend data for 24-hour periods in which natural conditions require heating reset control, supply-air temperature control, and economizer cooling control.

a) Minimum position input device.
b) Heating reset input device.
c) Supply-air temperature input device.
d) Cooling reset input device.

e. Acceptance Criteria:

1) Occupied Time Control: Mixed-air control is active in occupied mode.

2) Minimum Damper Position Control: Controller positions outdoor-air dampers to minimum position.

3) Heating Reset Control: Controller sets outdoor-air dampers to minimum position.

4) Supply-Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary supply-air temperature set point plus or minus 1.0 deg F.

5) Economizer Cooling Control: Controller sets outdoor-air dampers to mazimum position when outdoor-air enthalpy is less than return-air enthalpy.

6) Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.

7) Control Data Trend Log: Data verifies control according to sequence of control.

E. Fan-Coil Units

1. Fan-Coil Unit Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC". Provide submittals, test data, inspector record, and Fan-Coil Unit performance certification to the CxA. Fan-Coil Unit shall be equipped with all accessories as specified and scheduled and shall be demonstrated to deliver the scheduled airflow and heat capacity at no greater noise or power use levels than specified.

F. Finned-Tube Radiation

1. Finned Tube Radiation (FTR) Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC". Provide submittals, and test data certification to the CxA. FTR shall be installed level and plumb, neat and secure, with ready access to hydronic specialties as required for service, equipped with all accessories as specified and scheduled and shall be demonstrated to provide the specified and approved heating capacity while operating with no greater than the specified water flow.

G. Vibration, Sound, and Movement Control Systems

1. Coordinate Walk-through with CxA to verify installation is in accordance with specifications and submittals. Provide submittals, test data, inspector record, and Sound Attenuator performance certification to the CxA.

H. Energy Management and Control System

1. Testing requirements are specified in Division 23 Section "Instrumentation and Control for HVAC", Section 3.11 SYSTEM TESTING AND COMMISSIONING. Provide submittals, test data, inspector record, and EMCS performance certification to the CxA.

2. Provide password and any other hardware and software as required to enable CxA to communicate directly, with full graphics and control capability, with the EMCS from the CxA's office over an internet browser interface. Install complete early in project.

END OF SECTION 23 08 00

# SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

B. Review and study all drawings and this entire project specification to become familiar with the equipment and system operation as designed and to verify the quantities and types of controllers, valves, dampers, operators, alarms, points, etc., required.

### 1.2 SUMMARY

A. This section describes the requirements for a complete Energy Management and Control System (EMCS) for building mechanical systems and components, based upon Direct Digital Control (DDC) logic including WEB served operator interface via one new as well as the existing computer Operator Work Stations, distributed microprocessor controls, and integrated electronic components, interfaces, and actuation, all installed complete as specified.

B. Perform all work in cooperation with the Owner, Architect, Construction Manager, and other Prime Contractors. Coordinate all work with the construction schedule established by the Owner, Architect, and Construction Manager, and immediately report any delays including circumstances causing the delays.

C. It is the Owner's intent to establish a fully compatible and interoperable Energy Management and Control System (EMCS) network as an extension of the Lakeland's School District's distributed Technical Building Services (TBS) EMCS. The existing front end control system is a Tridium by Schneider Electric-I/A Series. For more information contact Jason Kross (518) 312-6086 at Technical Building Services, Inc. a Stark Tech Company

1. Operator Work Stations (OWS): Provide one new local laptop computer as a complete OWS, installed at a location of the Owner's choosing; and integrate this project's controls complete with the EMCS at the District's facilities offices and other buildings. Provide software and programming for new OWS and update software at existing EMCS complete to incorporate this addition. Provide guaranteed seamless two way communications from each, including full control, with the EMCS provided as a part of this project and the existing campus EMCS.

    a. The OWS shall monitor, display, and control information from the EMCS through one software package. Rebooting of the OWS, or opening a separate program to access the existing building's multiple systems is not acceptable.

    b. The new OWS shall meet the hardware and performance requirements of this specification.

c. The OWS shall allow customization of the system as described in this specification.

d. The OWS shall:

1) Provide new color graphic control panels for all equipment provided or modified as part of this project, as outlined below and on the drawings,
2) Allow operators to view and work with all DDC points associated with all DDC equipment provided or modified as part of this project,
3) Allow operators to create custom graphics and/or control programming generation for any and all new equipment.

2. Network Control Unit (NCU): Provide central processor WEB server capability for and fully integrated two way communications with all energy use and management equipment provided or modified by this project, along with any third party stand alone controls provided by the manufacturers of the Air Handlers, Refrigeration Machinery, Boilers, and Variable Speed Drives. NCU shall be capable of supporting a minimum of 127 field devices, providing reserve capacity for addition of future points and expansion of DDC system into building. The DDC system's NCU shall communicate with the OWS entirely using the BACnet protocol, with a conformance class of 5, as defined in the latest officially amended version of ANSI/ASHRAE 135-2004.

3. Distributed Controls: System controls shall include but not be limited to all controllers, sensors, devices, wiring, and all other hardware and software required to perform all of the functions and controls described later in this specification and on the drawings, including fully integrated two-way control of boilers, chiller, condensing units, pumps, VSDs, heat exchanger, and all associated temperatures, pressures, and other controllable parameters of mechanical equipment and systems provided or modified as part of this project. Provide control through the EMCS as outlined in the general controls sequences of operations below, as shown on the project drawings, and with controls similar to as shown where the exact configuration is not explicitly covered by the drawing and specification sequence of operations.

4. Engineer's Office: Provide password and any other hardware and software as required to enable Engineer to communicate directly, with full graphics and control capability, with the EMCS from the Engineer's office over an internet browser interface. Install complete early in project. Engineer will utilize to check progress of installation, to check operation of system during the punch list period, and to monitor system operation after completion of the work.

## 1.3 DEFINITIONS

A. DDC: Direct Digital Control.

B. PC: Personal computer.

C. EMCS: Energy Management and Control System, includes the complete automatic temperature control and energy use management system specified herein, based upon DDC technology, incorporating all necessary input and output devices, connecting hardware, software, and accessories.

D. OWS: Operator Workstation which is the main operator interface with the EMCS, comprised of a PC with graphical two way interface with, and data base and control capabilities for, the entire EMCS.

E. UC: Unitary Controller, a version of the SCU which is a smaller microprocessor-based controller, possibly pre-programmed to function specifically for the operation of a particular piece of equipment, such as a standard configuration air handler, unit ventilator, variable air volume box, lighting circuit, etc.

F. NCU: Network Control Unit, a secure central processing unit microprocessor based WEB server residing directly on the Owner's Ethernet TCP/IP LAN/WAN; providing direct communications to SCUs, UCs, and other field devices; integrating and processing their data and presenting it as custom HTML WEB pages in accordance with custom programmed graphical interface edited at an OWS.

G. LAN: Local Area Network - the Owner's existing Ethernet communications backbone which connects all of the owners buildings (and various rooms) on their campus. To be used by the Contractor where possible to connect OWSs, NCUs, SCUs, and UCs. Coordinate with Owner to determine extent of interconnection possible.

H. BACnet: A Data Communication Protocol for Building Automation and Control networks as defined in American National Standard ANSI/ASHRAE 135-1995, including any updates or revisions to this document.

I. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

J. MS/TP: Master slave/token passing.

K. I/O: Input/output.

L. Modbus: a serial communications protocol originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs).

M. PID: Proportional plus integral plus derivative.

N. RTD: Resistance temperature detector.

O. System Printer: a printing device which is installed on the LAN so that all EMCS components can utilize it as an output device.

P. TCC: Temperature Controls Contractor - The entity responsible for the work described by this section of specifications.

## 1.4 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 1 deg F.
   b. Space Temperature: Plus or minus 1 deg F.
   c. Ducted Air Temperature: Plus or minus 1 deg F.
   d. Outside Air Temperature: Plus or minus 2 deg F.
   e. Dew Point Temperature: Plus or minus 3 deg F.
   f. Relative Humidity: Plus or minus 5 percent.

## 1.5 QUALITY ASSURANCE

A. Provide all labor, material, equipment, software, and programming necessary to meet the functional intent of the EMCS, and the rigid requirements as specified herein and as shown on the drawings. Provide, without additional cost to the Owner, all equipment and labor not specifically referred to herein or on the plans, which are required to meet the functional intent expressed in the sequences of operations herein or on the drawings. The contractor is responsible for all costs of changes in the work required by substitute equipment.

B. The TCC must have been in business for at least ten years, providing DDC systems as their primary business with documented success. They shall have a minimum of five years as a manufacturer's authorized distributor or branch office representative for one or more of the manufacturers specified. They must have a trained staff of application engineers, project managers, software engineers, commissioning staff, training staff, and service staff experienced in the configuration, programming and service of the EMCS. They must have a local service department and stock the manufacturer's standard replacement parts.

C. The EMCS shall be installed only by skilled mechanics employed directly by the TCC except wiring may be installed by their first tier subcontractor under the TCC project manager’s direct supervision. Any subcontractor shall have documented success installing controls with the TCC for a minimum of five years prior to this project. Sub-contractual relations shall in no way relieve the contractor of any of their obligations under their contract.

D. The TCC shall have a training facility with regularly scheduled training as outlined below so as to provide ongoing regularly scheduled application training.

E. Manufacturer must be a firm regularly engaged in manufacture of microprocessor temperature control equipment, of configuration and capabilities similar to or better than specified equipment, for at least ten years, and must have similar earlier vintage models that have been in continuous satisfactory use for not less than ten years in similar service.

F. All work shall conform to the following Codes and Standards, as applicable to the Contracted Work at the Project job site and to the relevant Authorities Having Jurisdiction at the Project site. All products shall be labeled with the appropriate approval markings. In the case of conflict or discrepancy, the latest and most stringent regulation or code shall apply.

1. National Electrical Code (NEC) and applicable local Electrical Codes.
2. Underwriters Laboratories (UL) listing and labels.
3. Underwriters Laboratories of Canada (ULC) listing and labels.
4. UL 864 UUKL Smoke Control.
5. UL 864 UOJZ Fire Protection Signaling Systems.
6. UL-873; Temperature Indication and Regulating Equipment.
7. UL-916; Energy Management Systems for BAS components and ancillary equipment.
8. NFPA 70 – National Electrical Code.
9. NFPA 92A and 92B Smoke Purge/Control Equipment.
10. Factory Mutual (FM).
11. American National Standards Institute (ANSI).
12. National Electric Manufacturer's Association (NEMA).
13. American Society of Mechanical Engineers (ASME).
14. Institute of Electrical and Electronic Engineers (IEEE).
15. American Standard Code for Information Interchange (ASCII).
16. Electronics Industries Association (EIA).
17. Occupational Safety and Health Administration (OSHA).
18. American Society for Testing and Materials (ASTM).
19. Federal Communications Commission (FCC) including Part 15, R.F. Devices.
20. Americans Disability Act (ADA).
21. Uniform Building Code (UBC).
22. NEMA 250 – Enclosures For Electrical Equipment (1,000 V Maximum).
23. NFPA 101 – Life Safety Code.
24. IESNA – Illumination Engineering Society of North America.
25. UL 50 – Cabinets and Boxes.

## 1.6 GUARANTEES

A. Guarantee the EMCS complete to be free from defects in durability, materials, and workmanship, except for damages from other causes, for a period of one year after final acceptance.

B. Guarantee System to:

1. Maintain temperatures within +/- 1ºFof setting, within capacity of HVAC equipment.

C. Provide a one (1) year maintenance agreement to run concurrently with the Guarantee period, consisting of 24 hour emergency service and scheduled service (once per month minimum), as required addressing reported issues, for inspection and adjustment of operating controls, and replacement of parts or instruments found deficient or defective during this period.

D. Provide system backup and restore, software, programming, and sequence of operations enhancements, revisions, and adjustments at no charge to the Owner both during construction and commissioning and during this warrantee period.

## 1.7 SEQUENCE OF OPERATION

A. Refer to controls schematic drawings including written sequence of operations for specific pieces of equipment. Provide controls as specified and as required to achieve sequence of operations shown on drawings as well as specified below in general programming, and with controls similar to as shown where the exact configuration is not explicitly covered by the drawing and specification sequence of operations.

## 1.8 SUBMITTALS

A. Submit on controls in multiple portions as job progresses Include in each submittal a summary just inside the cover sheet of previously approved portions of submittal, currently submitted portions, and those portions not submitted yet. During closeout documentation, assemble all approved controls submittals into one package designed for use as both an installation and a maintenance manual.

B. Submit a Technical Proposal within 30 days of contract award or earlier as required for expedited construction schedule, complete with the diagrams, Specification Compliance Reports, product information, and supporting documentation outlined below. Arrange the Technical Proposal in order of the specification article numbers, with tabs (bookmarked .pdf files for electronic submittals) at each division. The Technical Proposal shall be designed for use as both a clear demonstration of qualifications and as an installation and maintenance manual. Progress submittals specified under paragraph 1.8.D below will not be reviewed prior to approval of the Technical Proposal submittal. Do not begin any demolition or new controls work prior to approval of the Technical Proposal.

C. Include the following in a complete Technical Proposal:

1. Description of service capabilities including resumes for service technicians and designers that will be responsible for this project.

2. A list of local jobs (three minimum) of similar type and size the bidder has installed, utilizing the products proposed for this project, with Owner's representatives and engineer of record's names and telephone numbers for reference. This list should directly reflect:

a. Projects that include direct integration to third party microprocessor controllers of the type specified within this scope.

b. For all proposed TCCs other than the specified basis of design, include projects with successful complete two-way communication and integration or replacement of the basis of design EMCS, including full transparent control and programming capability from the single workstation.

3. Submit name of any proposed installation subcontractors, along with their statement of qualifications, resumes for service technicians who will be responsible for this project, and 3 local references for comparable recent jobs.

4. EMCS network wiring diagram showing interconnection of all existing and new panels, workstations, system printer(s) etc., describing system architecture for this project with product code numbers for workstation, network controllers, application specific controllers, transducers, sensors, communication networks, etc.. Include all components intended to be used to meet or exceed specification requirements, shown in their functional relation to one another. Obtain from Owner and include the current EMCS system architecture diagram and complete existing control point list prior to any demolition and demonstrate intent to integrate all current control points into the EMCS work.

5. Provide information on owner training provided as part of the bid package as well as additional opportunities and factory schools available with associated costs. Include details of Operator HVAC Training System as specified herein.

6. Specification Compliance Report. The specification compliance report shall address every paragraph within this specification (230900), utilizing an outline format indicating clearly how the proposed system complies with this specification as follows:

   a. No Exception - proposed system complies without exception to both the letter and intent of this specification. Include Data Communications Protocol Certificates certifying that each proposed DDC system component complies with ASHRAE 135.

   b. Substitution Exception - proposed system is believed to meet the functional intent, but not the letter of the specification. For each paragraph for which a Substitution Exception is taken, the Specification Compliance Report shall identify all deviations from what is specified in the given paragraph and provide a complete description of what is included and how the proposed substitution meets the functional intent.

   c. Non-Compliance Exception - proposed system does not meet specification letter or functional intent, and the contractors intent is that the paragraphs requirements will not be provided. For each paragraph for which a Non-Compliance Exception is taken, the Specification Compliance Report shall identify all deviations from what is specified in the given paragraph and provide a complete description of what is included and why the contractor believes their proposed system should still be considered in spite of the non-compliance

   d. For all paragraphs indicated as “No Exception” or “Substitution Exception”, provide and reference factory product documentation to substantiate compliance.

7. Hardware Product Data Bulletins for all specified products, including PC components of OWS. Each bulletin shall describe product features, model numbers and manufacturer’s name.

8. Software Product Data Bulletins for all specified software features. Each bulletin shall describe product features, model numbers, and manufacturer's name.

D. As job progresses and in ample time for review and iteration as required for complete approval, submit the following:

1. Complete written description of all proposed control sequences and control strategy, with any deviations from the specified sequence of operations highlighted and explained.

2. Detailed wiring and piping control diagrams and system description for each system.

3. Detailed layout and nameplate list for all control panels, including pneumatic, unit-specific controllers, data-gathering panels, microprocessor-based panels, third party microprocessor controllers, etc.

4. Damper schedule giving size, type, velocity, pressure drop, configuration, location, and number, type, and size of motorized actuators. Include apparatus bulletins and data sheets. Include all existing to remain dampers proposed for reuse along with comments on condition.

5. Valve schedule giving valve identification tag abbreviation, location, service, failsafe position, pipe size, valve size, make/model, type, configuration, design flow, capacity index (cv), and pressure drop. Include apparatus bulletins and data sheets.

6. Schedule showing direct integration to all third party microprocessor controllers included in this project, including all points available in a point listing describing point type (analog input, binary input, analog output and binary output), point address, units, applicable software interlocks (alarm, interlock, sequence, etc.), and a verbal description of the function and intended control of the point.

7. Termination schedule and point listing describing point type, (analog input, binary input, analog output and binary output), physical point location (eg. AHU #1 mixed air) and software interlocks (alarm, interlock, sequence, etc.).

8. A complete listing of inputs and outputs, control loops and/or routines, timing functions, and facilities management system functions for each controlled system. This listing shall include point logical names and identifiers.

9. For all equipment, submit copy of written installation, maintenance, and operating directions and details, along with manufacturer's printed installation instructions for all equipment furnished, showing required installation and location of the above items.

10. Provide a sample of program language and description of how programming is accomplished.

11. Color printout sheets of representative samples of all proposed graphics and text based OWS pages.

E. 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.

F. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
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.

## 1.9 RELATED AND ANCILLARY WORK

A. Electrical control wiring associated with building fire alarm system and duct smoke detectors: Installation is specified under Division 26.

B. Power source wiring for general (non-controls) HVAC motorized equipment: Installation specified under Division 26.

C. Provide power source and controls wiring for all EMCS equipment, complete back to breakers designated as temperature control power breakers on electrical drawings or other approved electrical power panel space. Includes all controls power source wiring, communication wiring, and actuated device power and control wiring. Installation specified both herein and in applicable sections of Division 26.

D. Piping work as required to maintain pressure tight integrity of all hydronic, potable water, and refrigerant based systems for the installation of all piping mounted controls components, including control valve installation, valve and control manifolds, pressure and temperature taps, flow switches, thermal wells, and similar devices: Installation specified both herein and under applicable piping section.

E. Sheet metal work as required to maintain pressure tight integrity of all airside systems for the installation of all airside mounted controls components, including dampers, pressure and temperature probe taps, flow sensors, and similar devices: Installation specified both herein and under applicable sheet metal and ductwork sections.

F. Insulation work as required to maintain the thermal integrity of the various systems associated with and subsequent to controls component installations: Installation specified in Division 23 section on Insulation.

G. For all equipment: Provide and follow written installation directions and details, with manufacturer's printed installation instructions for all equipment furnished, showing required installation and location of the above items.

## 1.10 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 submittal, approval, fabrication, and shipping of control devices to equipment manufacturer in ample time for factory installation without impacting project schedule.

B. System Software: Update to latest version of software at Project completion.

## 1.11 INSTRUCTION AND TRAINING

A. Factory Authorized Control System Training:

1. Provide factory trained and authorized instructors and control technicians to instruct the Owner's operating personnel.

2. Factory authorized on site training - Provide two (2) on site training sessions each four (4) hours in duration covering network layout, controllers, and software functions. Both generic and product specific training shall be provided. Sessions shall be scheduled by the Contractor at the Owner's convenience, at any time up to two years after system installation.

3. Factory authorized on site training - Provide six (6) on site training sessions each four (4) hours in duration covering network layout, controllers, and software functions. Both generic and product specific training shall be provided. Sessions shall be scheduled by the Contractor at the Owner's convenience, at any time up to two years after system installation.

4. Factory authorized off site training - Provide three (3) day factory authorized off site training course for up to two Owner's representatives, covering advanced topics related to their EMCS, including graphics modification and creation, control software programming, system communications, remote communications, database management, and trouble shooting. Include all incidental expenses.

5. Provide videotaping and audio taping of all training sessions, both off and on site. Turn over two copies of tapes and three copies of maintenance manual to Owner's representative.

B. Include in closeout documentation signed letter of acknowledgment of receipt of factory authorized training, videotapes, and maintenance manuals.

## 1.12 COORDINATION

A. Coordinate all controls work required for a complete operable controls system as specified. Carefully review project summary and scoping documentation and coordinate with contractors responsible for various ancillary portions of controls work. Where supportive or ancillary work is not specifically assigned to another contractor, provide complete as required for a complete operable system.

B. Coordinate equipment with Division 28 Sections on Fire Detection and Alarm Systems to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Division 26 Sections on Panelboards to achieve compatibility with starter coils and annunciation devices.

E. Coordinate size and location of concrete bases. Refer to Section 23 05 00 – COMMON WORK RESULTS FOR HVAC SYSTEMS for additional information.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Temperature Control Sub-Contractors (TCCs): Existing Energy Management and Control System (EMCS) and Basis of Design Energy Management and Control System (EMCS) is TAC / Tridium / Niagara Controls as installed by TBS, Starktec, Inc.

B. Subject to compliance with requirements, available TCCs offering products and services that may be incorporated into the Work include, but are not limited to, the following:

1. Automated Logic Controls as installed by Logical Control Solutions.
2. Delta Controls as installed by EMCOR Services Tri-Tech.
3. Johnson Controls Incorporated as installed by JCI.
4. Schneider Electric Controls as installed by Day Automation.
5. Siemens Controls as installed by Siemens Building Technologies, Landis Division.

C. In other Part 2 articles where specific components are described, the basis of design and named equivalent TCCs integrate multiple manufacturers' components into a coherent system. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified:

1. Armstrong
2. Automated Logic Corporation.
3. Functional Devices Inc.
4. Honeywell International Inc.; Home & Building Control.
5. Invensys Building Systems.
6. Johnson Controls, Inc.; Controls Group.
7. KMC Controls/Kreuter Manufacturing Company.

8. McQuay International.
9. Siemens Building Technologies, Inc.
10. Schneider Electric
11. Solidyne Corp.
12. Staefa Control System Inc.; Siemens Building Technologies, Inc.
13. TAC Americas, INC.
14. TCS/Basys Controls.
15. Tekmar Control Systems, Inc.
16. Teletrol Systems Incorporated.
17. Tour & Andersson Control, Inc.
18. Trane; Worldwide Applied Systems Group
19. Triangle MicroSystems, Inc.
20. Victaulic, Inc.
21. Voltec, Inc.

## 2.2 GENERAL SYSTEM ARCHITECTURE

A. The EMCS shall consist of the following:

1. Operators' Workstations (OWS).

2. File Server (FS).

3. Network Control Units (NCU).

4. Application Specific Unitary Controllers (UC).

5. All controls power wiring 120 volts or less, all network and communication wiring, fiber optic cable, and other controls communication media.

6. All EMCS communications devices.

7. All related field devices including remote I/O cabinets, transformers and power supplies, relays, contactors, transducers, switches, cabling, and related electronic control equipment.

8. All necessary software and custom programming, including graphics and reports.

9. All necessary inputs, outputs, and devices required to meet the features and intent described herein including but not limited to:

    a. Transducers.
    b. Differential Pressure sensors.
    c. Hydronic control valves.
    d. Opposed blade (control) or parallel blade (shutoff), low leakage dampers.
    e. Temperature, and humidity sensors and safety devices.
    f. Electronic valve and damper actuators.

10. All other equipment necessary for a complete, operational, EMCS.

B. The design of the EMCS shall network OWSs, FCs, NCUs, UCs, and all sensors, safeties, actuators, and other devices. Inherent in the system's design shall be the ability to expand or modify the network via the Internet, the Level 1 LAN, the Level 2 bus, or via auto e-mail or auto-dial telephone line modem connections, or via a combination of all four networking schemes. LAN communications between buildings shall be standard ETHERNET TCP/IP and shall be compatible with the district's existing ETHERNET LAN.

C. The EMCS shall:

1. Be modular in nature, with distributed controllers operating in multi-user, multi-tasking environment on token-passing network.

2. Be re-programmable and programmed to control mechanical, electrical, and plumbing systems.

3. Be capable of integrating multiple building functions, equipment supervision and control, alarm management, energy management, historical data collection, and archiving.

4. Permit expansion of both capacity and functionally through the addition of components and programming.

5. Include an operator workstation which permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

6. Not be dependent upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. The system architecture shall consist of no more than two communication levels as follows:

1. Level 1 shall be on the Owner's ETHERNET LAN as possible within the constraints of this specification. Contractor shall field verify extent and capacity of existing LAN with Owner prior to creation of network layout drawings, and shall include any and all extensions of the LAN required for complete and robust functioning of the EMCS:

a. Level 1 communications shall use the BACnet protocol.

b. This LAN operates under ETHERNET protocol at 10 Mbps or other speed as determined by the Owner. The Level 1 LAN will provide transfer of point data, alarms and file activity among OWSs, NCUs, and SCUs.

c. Any data from a Level 2 controller can also be transmitted onto this bus through a Level 1 controller. The high speed LAN shall support multi-user communications and multi-session activity. That is, all global data sharing shall occur simultaneously with the transmission of alarm data or user activity.

d. OWSs and NCUs shall reside directly on the LAN such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations, on a peer-to-peer basis.

e. SCUs and UCs may reside directly on the Level 1 Lan at the TCCs option.

2. Level 2 shall be on a EIA-485 bus or other comparable technology, designed to support a family of dedicated local controllers for control of HVAC equipment and lighting. The Level 2 bus shall communicate bi-directionally with the Level 1 LAN through NCU controllers for transmission of global data:

a. The Level 2 bus, or field bus, shall support local control units (SCUs and UCs) of modular size for operation of the building's HVAC and lighting systems. This bus shall operate at a minimum speed of 200 kbps with a length of 4000 feet and 10Mbps with a length of 150 feet, with 32 nodes before requiring a network repeater. A minimum of 127 controllers shall be configurable on the field bus.

b. The field bus shall permit peer-to-peer communications among all Level 2 controllers and allow simultaneous communications with portable computer service tools that are connected to a Level 2 controller. Failure of any Level 1 NCU controller shall not impair the operation of its associated field bus.

c. All Level 2 field wiring that connects non native BACnet unitary controllers shall have an additional wiring set run in parallel dedicated for future use by native BACnet replacement controllers.

E. NCUs shall be able to access any data from, or send control commands and alarm reports directly to any other NCU or combination of NCUs on the network without dependence upon a central processing device. NCUs shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

F. Dynamic Data Access:

1. All operator devices, network resident, internet connected, or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the LAN. Access to data shall be based upon logical identification of building equipment.

2. Access to system data shall not be restricted by the hardware configuration of the EMCS. The hardware configuration of the EMCS network shall be totally transparent to the user when accessing data or developing control programs.

3. All points contained on Level 1 and Level 2 controllers shall be considered global points. Any program in any controller on the network shall be able to reference any point in any controller regardless of its location on the network.

G. General Network Design:

1. Network design shall include the following provisions:

a. Data transfer rate for alarm reporting, report generation from multiple controllers, and upload/download between SCUs and OWSs shall be a minimum of 2.5 Megabaud.

b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

c. Detection and accommodation of single or multiple failures of either OWSs, SCUs, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

d. Message and alarm buffering to prevent information from being lost.

e. Error detection, correction, and re-transmission to guarantee data integrity.

f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

g. Commonly available, multiple sourced, networking components and Ethernet protocols shall be used to allow the EMCS to coexist with other networking applications on the Owner's existing LAN/WAN. Ethernet and BACnet are acceptable technologies. BACnet system shall conform to the latest ASHRAE Standards and recommendations.

h. Use of an industry standard IEEE 802.x protocol.

i. Provide synchronization of the real-time clocks in all EMCS panels.

## 2.3 OPERATOR WORK STATION (OWS)

A. Provide FCC certified class B computer systems as the OWS to control operator input/output, data storage and transmission to and from the system controllers, and to perform all software functions as noted hereafter. Provide hardware and software commercially available nationally from local vendors, with repair parts and service available locally from these vendors. Provide computer products by one of the following:
1. Dell or equal

B. Provide one laptop style PC based computer with minimum configuration as follows to serve as the building OWS:

1. INTEL Core i7 2.8 GHz, 667MHz FSB, 4MB L2 cache microprocessor

2. Minimum 32GB dual-channel DDR2 1333MHz SDRAM memory.

3. 17" diagonal 1920x1200 Ultrasharp Active Matrix WUXGA display

4. Provide integrated stereo speakers and sound card.

5. Provide an on board Combo Drive: 24x/10x/24x CD-RW and 8x DVD-ROM.

6. Provide an internal hard disk drive (minimum 512 GB) with average access time of less than 30 milliseconds and a file transfer rate of at least 30Kbaud for storage of primary system data base and operating parameter files.

7. Provide two (2) parallel and two (2) serial communications ports. The serial communications ports shall be capable of transfer rates of at least 9600 baud (RS-232-C standard). Provide at least four unused USB 2.0 ports.

8. Provide built-in ethernet networking capabilities (10/100Mbits) and wireless capability.

9. Provide graphics controller similar to 512MB NVIDIA® GeForce® GO7950 GTX.

10. Accessories:

    a. Provide a black and white printer laser printer with parallel and network interface, twelve pages per minute minimum at 1200 dpi equivalent, ½ ream paper storage minimum, dual side printing.

    b. Provide a 20" flat panel monitor with 20.1-inch viewable, LCD, TFT, Midnight Gray, Up to 1600x1200 Pixels, 0.255 mm Pixel Pitch, Anti-glare with Hard Coating, 15-Pin D-Sub / 24-Pin DVI-D / S-Video / Composite Video / USB 2.0 Connectors.

    c. Provide docking station allowing laptop to be easily connected to mouse, printer, larger screen, etc., all connected through a UPS.

    d. Provide an optical mouse, two buttons and wheel, to serve as the pointing device.

    e. Provide a soft-side rainproof ballistic nylon carrying case, with padded secure compartments for laptop and all accessories.

    f. Provide a UL listed 1500 VA minimum UPS with surge protector, with at least six (6) electrical outlets, one (1) cable outlet, and one (1) modem outlet.

C. Software

1. Operating System: Microsoft Windows 10 Business / Enterprise Professional, or comparable OS (verify with Owner and provide system compatible with Owner's IT system), with high-speed Internet access.

2. EMCS Application Software General Requirements:

    a. The software shall communicate with the existing EMCS over the Owner's LAN using ASHRAE 135 and ISO 8802-3 (Ethernet) datalink/physical layer protocols.

    b. The software shall be a standard application for the off the shelf MS Windows OS selected above, and shall not require a dedicated OWS, nor a different operating system from the Owner's other office management software.

c. Standard utility software packages shall be available through local retail outlets.

d. The OWS shall output advisories and unacknowledged change-of-state or out-of-limits occurrences in a dedicated and protected area of the viewing screen.

e. Graphical and Text Based Displays: At the option of the user, Operator workstation shall provide consistent graphical or text based displays of all system points and application data described in this specification. Point identification, engineering units, status indication and application naming conventions shall be the same at all workstations.

f. Individual point information shall be coded via eight different colors. These colors shall be defined with respect to system type and condition.

g. Multiple, Concurrent Displays: provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance. If the interface is unable to display several different types of displays at the same time, the TCC shall provide at least two networked operator stations.

h. Employ browser-like functionality for ease of navigation, with a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. Provide menu-pull downs and toolbars, "hot-button" commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System or basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

i. Provide for modifying common application objects, such as schedules, calendars, and set points in a graphical manner, for example using a graphical slider, without requiring operator keyboard entry.

3. Application Software Features:

a. Security:

1) The software shall be designed so that up to 256 users of the software can each have a unique username and password. Each username/password combination shall be linked to a set of capabilities within the software, set and editable only by a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. Passwords shall be changeable through on-line keyboard entry by either the individual user or the administrator.

2) There shall be an adjustable inactivity timer that automatically logs off the current operator after the timer has expired.

3) Record all operator inputs executed under a valid password in a data log, including operator name.

4) At no time shall the actual password numbers be printed on the screen, except for operators with the strictest level of password, who shall be able to generate a password summary listing.

a) The password summary shall include at least a 24-character name, login ID, password, time out value, and security level.

5) Passwords shall be exactly the same for all operator devices, including stationary or portable OWS, or panel mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all EMCS panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for EMCS panels individually.

6) Operators will be able to perform only those commands available for their respective passwords. Menu selection displayed at any operator device, including portable or panel mounted devices, shall be limited to only those defined for the access level of the password used to log on.

7) Provide user definable, adjustable, automatic log off timer to activate after from 1 to 60 minutes of inactivity (adj.), to prevent operators from inadvertently leaving devices online.

b. I/O capability from each OWS

c. Automatic system diagnostics; monitor system and report failures.

d. Database creation and support.

e. Automatic and manual database save and restore.

f. Object and property status and control.

g. Automatic restart of field equipment on restoration of power.

h. Custom report development.

i. Utility and weather reports.

j. Workstation application editors for controllers and schedules.

k. Maintenance management.

l. Trend logs: Support customized trend log reports with variables assignable at the OWS, automatic archive of trended values, with data retrievable in spreadsheets and database programs.

m. Data collection, reports, and logs. Include standard reports for the following:

1) Current values of all objects.
2) Current alarm summary, sorted by priority.
3) Alarm history.
4) Disabled objects.
5) Alarm lockout objects.
6) Logs.

n. Summaries:

1) System log shall log the status of points within system.
2) Alarm summary shall log specified alarm points which are actually in alarm.
3) Off-normal summary shall log points specified by the operator to be in the off-normal mode.
4) Lockout summary shall log points specified to be in the lockout condition.

o. Messages:

1) The system shall support a minimum of 500 different automatic messages defined by the authorized operator on-line via word processing editor with minimum available length of 256 alpha-numeric characters. Messages shall also indicate whether acknowledgment is necessary.

2) Messages may be assignable as pop-up reactions to operator inputs, system alarms, event processes, and other system messages as required and deemed useful by the programmer, Engineer, and Owner.

p. Totalization:

1) The energy management system shall allow for analog or digital point totalization with respect to time.

2) Run time totalization shall be provided to track the run time of point assigned. A summary shall be generatable listing run time points and their present values.

3) Analog totalization shall be provided to measure analog data over real time span. A summary shall be generatable which lists analog totalization points and their current period values, current dry values, previous period and previous day totalized values.

4) Provide customized totalization reports for each major HVAC system.

q. Scheduling:

1) The system shall be capable of initiating equipment based on a preselected time-of-day schedule. This program shall provide scheduling for seven days of the week with 500 unique schedules. The user shall not be required to enter control programs to alter time-of-day schedules.

2) Provisions shall be made to program in holidays up to one year in advance; up to 366 consecutive holidays shall be enterable.

3) On-Line Graphic Generation:

4) This program shall allow the operator to generate color graphics on-line using symbols selected from a standard library of symbols.

4. Energy Management Features: The following energy management programs shall reside in the OWS for global control purposes:

a. Demand limiting program shall monitor total demand at the on-site meter and reduce load, if possible, to maintain a fixed value.

b. Duty cycling program shall periodically turn selected loads off to reduce energy consumption.

c. Optimal run time program shall control the start-up and shutdown of HVAC equipment based on the most energy efficient schedule. Startup shall be staggered to minimize inrush currents.

d. The energy management program shall not allow the energy management features listed above to shut down air systems (air handling units, unit ventilators, cabinet heaters, etc.) which are providing ventilation air to the occupied spaces during the occupied cycle.

e. Programs shall be supervised by an energy management program, which shall oversee the execution of global energy management functions. These programs may also reside in individual field panels on systems of this architecture. If the host computer is to act only in a supervisory mode, specific panels shall be assigned to global function duty.

5. 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.

6. Control Programming: Definition of operator device characteristics, EMCS panels, individual points, application, and control sequences shall be performed through fill-in-the-blank templates and a graphical programming approach. Allow the user to define the software configuration of EMCS panel logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

a. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting lines between symbols and depicting inputs, operators (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:

1) Process inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
2) Mathematical process operators, such as addition, subtraction, multiplication, or greater than, equal to, or less than, etc.
3) Logical process operators such as IF, AND, OR, ELSE, GO TO, Exclusive OR, NOT, etc.
4) Time delays.
5) Process control outputs such as start/stop control points, analog adjust points, etc.
6) Process calculation outputs.
7) Text file outputs and advisories.

b. Network-wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single EMCS panel, but shall be able to include data from any and all other EMCS panels to allow the development of network wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

c. Sequence testing and simulations: Provide a software tool which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data and verify desired control response and calculation results via graphical displays and hard copy printouts.

7. Dynamic Color Graphic Displays:

a. Provide graphics generation software to allow the user to add, modify, or delete system graphic displays that include any manipulated point data from any networked EMCS panels, including SCUs or Ucs. Develop graphic screens using any drawing package capable of generating a GIF, BMP, or JPG file format, including AutoCadd and Visio. Use of proprietary graphic file formats shall not be acceptable. In addition to a graphic background, support the use of scanned pictures.

b. Provide for simultaneous viewing of several graphics at the same time (windowing) to analyze total building operation, or to allow display of a graphic associated with an alarm to be viewed without interrupting work in progress.

c. Provide libraries of pre engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume terminal reheat, VAV, etc.) and electrical symbols.

d. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

1) Define symbols

2) Position and size symbols
3) Define background screens
4) Define connecting lines and curves
5) Locate, orient, and size descriptive text
6) Define and display colors for all elements
7) Establish correlation between symbols or text and associates system points or other displays.

e. Each graphic display shall consist of a static section and a dynamic section. The static section shall consist of elements which usually do not change with time or point condition. The dynamic section shall consist of elements which usually do change with point conditions, and shall be integrated with the respective static section, appearing in appropriate locations in it.

1) A minimum capability of 256 different static sections shall be provided. Each static section shall be capable of being associated with any number of dynamic sections. The elements of a static section shall be capable of outputting in any one of eight different colors. A static section does not have to be associated with a dynamic section to be used as chromatic output. The elements of static sections shall include, but not be limited to: lines, line drawings, symbols, and character strings (single/double sized).

2) The dynamic section shall accommodate a minimum of 40 elements. The elements of a dynamic section shall be capable of outputting in any one of the eight colors. Symbols shall be a pictorial illustration of the point condition. This illustration shall not be dependent on the type of sensor/device being represented. The elements of a dynamic section shall include, but not be limited to: point identifier, point expanded identifier (if abbreviated), analog value, engineering units, mode units, symbols, lines, text strings. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

3) System graphic display shall update the dynamic elements to the current point condition, at least every 30 seconds. System shall include a list of standard symbols. Lines shall include, but not be limited to: vertical, horizontal, diagonal, curved. Character strings shall include alpha/numeric characters and shall be capable of 60 characters minimum length.

4) Dynamic element shall be capable of being used a multitude of times on a single chromatic display and shall be stored in a symbols library program.

f. When a point is in alarm on the screen, the OWS shall be able to display an alarm graphic with a minimum number of keystrokes. Alarm graphic individual point information shall include, but not be limited to: point identification, point location, alarm point value, alarm limit value, engineering units ($^{o}$F, KWH, etc.), mode units (on/off, alarm).

8. Web Browser Features:

   a. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

   b. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

   c. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

   d. Alarm Console:

      1) The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.

      2) When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

9. Web Browser Clients

   a. The system shall be capable of supporting at least 64 clients using a standard Web browser such as Google Chrome, Safari, etc. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, are only acceptable if 64 licensed copies of the client machine software are provided, installed, and tested. The system shall support a minimum of ten (10) simultaneous clients.

   b. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the EMCS, shall only be acceptable if 64 workstation or workstation hardware upgrades are provided.

c. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

d. The Web browser client shall support at a minimum, the following functions:

1) User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

2) Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.

3) HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

4) Storage of the graphical screens shall be in the Building Control Units (BC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

5) Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

6) Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

a) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.

b) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

c) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

d) Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

e) View logs and charts

f) View and acknowledge alarms

7) The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

8) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

## 2.4 NETWORK CONTROL UNITS (NCUs)

A. General: Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of NCUs shall be supplied to fully meet the requirements of this specification and the controls requirements shown on the drawings.

1. Basis of design NCUs: Schneider Electric Continuum bCX1-CR-xxx with InfbCX1 controller.

B. Webserver Functionality: All NCUs shall reside directly on the Owner's Ethernet TCP/IP LAN/WAN and shall be capable, out-of-the box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and "serve" pages to a web browser. Provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer™, Netscape Navigator™, etc.) to access real-time data from the entire BAS via any NCU.

1. Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

2. The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller, process, or network interface (BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

3. The BAS network controller must act directly as the WEB server. It must directly generate HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored in any shared network device. The BAS Web server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory: A minimum of 4MB of RAM shall be provided for NCUs with expansion up to 8MB. The 8MB versions shall include a floating-point math co-processor.

2. Communication Ports: Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU shall have at least three other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system, the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

3. Input/Output (I/O): Each NCU shall support the addition of the following types of inputs and outputs:

   a. Digital Inputs for status/alarm contacts
   b. Counter Inputs for summing pulses from meters.
   c. Thermistor inputs for measuring temperatures in space, ducts and thermowells.
   d. Analog inputs for pressure, humidity, flow and position measurements.
   e. Digital Outputs for on/off equipment control.
   f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

4. Modular Expandability: The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

5. Real Time Clock (RTC): Each NCU shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation, the system clock shall be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.

6. Power Supply: The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (–48 VDC).

7. Automatic Restart After Power Failure: Upon restoration of power after an outage, the NCU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

8. Battery backup: Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit shall shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software Specifications

1. General: The NCU shall contain flash ROM as the resident operating system. Application software shall be RAM resident. Application software shall only be limited by the amount of RAM memory. There shall be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language: The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The NCU shall have the ability to perform the following pre-tested control algorithms:

   a. Proportional, Integral plus Derivative Control (PID)
   b. Two Position Control
   c. Digital Filter
   d. Ratio Calculator
   e. Equipment Cycling Protection

2. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These shall be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications: NCUs shall have the ability to perform any or all of the following energy management routines:

   a. Time of Day Scheduling
   b. Calendar Based Scheduling

c. Holiday Scheduling
d. Temporary Schedule Overrides
e. Optimal Start
f. Optimal Stop
g. Night Setback Control
h. Enthalpy Switchover (Economizer)
i. Peak Demand Limiting
j. Heating/Cooling Interlock
k. Hot/Cold Deck Reset
l. Free Cooling
m. Hot Water Reset

4. History Logging: Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32,767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the NCU and can result in the display of one or more alarm messages or reports.

6. Up to 8 alarms can be configured for each point in the controller.

   a. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device.

   b. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.

   c. If communication with the Operator Workstation is temporarily interrupted, the alarm shall be buffered in the NCU. When communications return, the alarm shall be transmitted to the Operator Workstation if the point is still in the alarm condition.

7. Reporting: The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

## 2.5 I/O INTERFACE

A. Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

B. Binary Inputs: Allow monitoring of on-off signals without external power.

C. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

D. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

E. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

F. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.

G. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

H. Universal I/Os: Provide software selectable binary or analog outputs.

## 2.6 POWER SUPPLIES

A. Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

B. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

## 2.7 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

## 2.8 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Current Switches and Transducers:

1. Self-powered fixed setpoint digital output current switch to provide load status and power use trending data for small fixed loads only.

    a. Solid or split core slips over loose power wiring (solid core) or clips over installed power wiring (split core).
    b. Fixed on switch 0.25A max (solid core) or 0.15A (split core).
    c. Capacity to 200A (solid core) or 150A (split core).
    d. Digital switch output, rated 1A@30VAC/DC.
    e. LED status light.
    f. Operating conditions: -15 to 60 deg C, 0 to 95% rh.
    g. Polarity insensitive.
    h. 100% solid state.
    i. CE and UL listed.
    j. 5 year warranty.
    k. Similar to Veris Hawkeye 600 (split core) or 800 (solid core).

2. Self-powered adjustable setpoint digital output current switch to provide load status, loss of belt/load, and power use trending data for small potentially variable loads.

    a. Solid or split core slips over loose power wiring (solid core) or clips over installed power wiring (split core).
    b. Adjustable on switch 1.0A max (solid core) or 0.5A (split core).
    c. Capacity to 135A (solid core) or 175A (split core).
    d. Digital switch output, rated 1A@30VAC/DC.
    e. LED status light.
    f. Hysteresis 10% max.
    g. Operating conditions: -15 to 60 deg C, 0 to 95% rh.
    h. Polarity insensitive.
    i. 100% solid state.
    j. CE and UL listed, RoHS compliant.
    k. 5 year warranty.
    l. Similar to Veris Hawkeye Hx08 series.

3. Self powered analog current transducer to provide combination load monitoring, status, and power use trending data.

    a. Solid or split core slips over loose power wiring (solid core) or clips over installed power wiring (split core)
    b. Linear output from 0 to full scale.
    c. 0-5Vdc or 4-20mA analog output
    d. Operating conditions: -15-60 deg C, 0-95%rh.
    e. 2 second response time.
    f. Use solid core for new applications, split core for retrofits away from terminals.
    g. +/- 2% of reading accuracy from 10% to 100%.
    h. 100% solid state.
    i. CE and UL listed, RoHS compliant.
    j. 5 year warranty.
    k. Similar to Hawkeye 722, 922/932, size and range as required for load.

4. Power Monitors:

    a. 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 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

C. Static Pressure Transmitter / Transducer:

1. Senses differential gauge (static) pressures and converts this pressure difference to a proportional analog output signal.

    a. Variable capacitance type, with stainless steel diaphragm and insulated positioning electrode.
    b. Voltage Requirement (input): +/- 12 V DC.
    c. Output: linear, 4 to 20 mA or 0 - 5 V DC.
    d. Pressure ranges 0 to 0.1 in w.g. through 0 to 25.0 in. w.g.
    e. Over Pressure Protection: Minimum 10 x full scale.
    f. Pressure Part Volumes: Positive part - 0.020 $in.^3$; reference part - 2.0 $in.^3$
    g. Accuracy: +/- 1% full scale (includes non-linearity hysteresis and non-repeatability).
    h. Factory calibrated with zero span adjustment capability.
    i. Temperature compensated output over the entire operating temperature range.
    j. Operating Environments: 40 deg. F to 100 deg. F.

D. Electronic Humidity Transmitter.

1. The electronic duct humidity transmitter shall sense duct humidity and shall transmit an electrical signal to the EMCS. A direct acting, proportional relationship shall be developed between the measured relative humidity and the transmitter output voltage,

2. Relative humidity shall be sensed by a cellulose acetate butyrate element and conveyed to a linear variable differential transformer. Changes in percent RH shall reposition the transformer core and create an imbalance in the secondary windings proportional to the magnitude of the RH sensed by the transmitter. The transmitter requires a +12 or +15 volt DC power supply. For a 10 to 100% RH input, the output shall be 0.5 to 5 volts with a +12 volt supply and 20 to 200 mV with a +15 volt supply. Change from one output range to the other shall be possible with a jumper.

3. The transmitter shall be provided with all electrical steel enclosure and cover; the element shall be protected with an aluminum guard.

    a. Action: Direct Acting, Proportional.
    b. Element: Cellulose Acetate; Butyrate-CAB.
    c. Operating Range: 10 to 100% RH.
    d. Supply Voltage: +12 volts DC, 60 mW (max.) or +15 volts supply -20 to 20 mV DC with a 15 volt supply.
    e. Output Signal: 0.5 to 5.0 volts DC with a 12 volt supply -20 to 20 Mv DC with a 15 volt supply.
    f. Load Resistance: 10k ohms with 0.5 to 5 volt output; 100k ohms with 20 to 200 Mv output.
    g. Accuracy: $\pm$ 2% of full scale (or RH) between 20 and 75% RH (includes non-linearity, hysteresis, and repeatability).
    h. Operating Environment: 40 to 125E F, 10 to 90% RH, non-condensing.

E. Temperature Sensors:

1. Temperature sensors shall be:

    a. Platinum wound RTD Type $\pm$ 1$^{o}$F. Factory calibration point - 70$^{o}$F at 1000 OHMS or 0$^{o}$C at 1000 OHMS. Adjustments for zero and span. Output 4-20 mA.

Or (for non averaging sensors)

    b. Contractor may use thermistors which are compatible with system as follows:

        1) Accurate to 0.35$^{o}$F over a range of -40$^{o}$ to 240$^{o}$F,
        2) Noncalibrated devices, accuracy traceable to NBS testing,
        3) Guaranteed stability of 0.2$^{o}$F over a 15 year period,
        4) Interchangable with any other in the new system, and
        5) Shielded cable not require for the guaranteed performance.

2. Room element assemblies shall be located in conditions representative of the zone, on an interior wall where air is free to circulate around the element but away from non-representative air conditions such as drafts or heat radiation. Mount the assembly 5 feet above the floor on a standard electrical wallbox, or as otherwise directed or required to obtain satisfactory results. A mounting bracket, wallplate, decorative cover and tamper resistant screens shall be furnished with the assembly. May be S.S. wall plate type where applicable.

3. Outside air temperature sensing: The outside air sensor shall be mounted where the effects of sunlight and radiant heat are at a minimum (north wall) for true “dry-bulb” reading. Provide in enclosure to fit 1/2" threaded rigid conduit, designed for exterior dry-bulb sensing. Seal off fittings shall be used to prevent condensation on the element in the housing. Monitoring range to suit controls.

4. Duct temperature sensors: Duct insertion sensors for fan discharge and other thoroughly mixed applications designed for control and/or indication shall have a single sensor with an accuracy of 0.25% of scale range. Provide averaging type sensing elements for transmitters and capillary thermostats in mixed air and coil discharge applications to counteract effects of stratification. Length as required to provide at least four full passes across the duct – two long dimension and two diagonal. Capillary systems to be fully compensated. The element shall consist of nickel wire encased in a copper tube. Monitoring range to suit controls.

5. Liquid temperature sensors shall be mounted in separable brass immersion wells with 1/2" - 14 NPT threads, filled with "Insulgrease" or other approved heat transfer compound. Monitoring range to suit conditions. Well and spring loading device to assure RTD contact with end of sensing well. Whenever a sensing element and well are installed in a chilled water line, plumber's putty or some other suitable sealant shall be applied around the adapter as well as the point where the two sensors leads pass through the adapter. This is to prevent condensation of moisture in the well and failure of the element. Minimum well length to be equal to 1/2 of the pipe diameter; match bulb length to well length.

6. Battery powered “wireless communicating” sensors which use batteries as the source of power for transmission and communication of data are not acceptable.

F. Thermostats:

1. Electronic room thermostats shall be similar to room temperature sensors with occupancy over-ride, bias adjustment, and LCD space / setpoint temperature readout functions built in.

2. Provide with durable cast aluminum or polycarbonate guard where required to prevent unauthorized access.

3. Battery powered “wireless communicating” thermostats which use batteries as the source of power for transmission and communication of data are not acceptable.

4. Incidental electric thermostats specifically indicated as not connected to EMCS shall be heavy duty type with concealed adjustment.

## 2.9 HVAC PROCESS FLOW CONTROL COMPONENTS

A. Automatic Air Dampers (AAD on drawings):

1. Provide all automatic dampers except those specified as being furnished by equipment manufacturer. Thermally Insulated Automatic dampers are required at all exterior wall and roof openings serving a HVAC purpose which are provided or modified as a part of this project, whether or not called for on the drawings. Control dampers to operate with sequence described later or as directed.

2. Size dampers at full duct or damper size indicated on the drawings, arranged for flanged to duct rather than inserted in duct installation (clear damper opening, not outside of frame, equal to duct size indicated). If neither duct or damper size is indicated; size for maximum velocity of 1500 fpm and maximum pressure drop including transitions to and from duct 0.05 in w.g.

3. Materials:

    a. General-service dampers not covered by the below restrictions, in galvanized steel ductwork, may be of galvanized steel construction.
    b. Dampers subject to corrosive fumes: stainless steel of a type resistant to the fumes.

4. Overall Construction:

    a. Damper frames fabricated of extruded aluminum sections or formed steel, with reinforced corner bracing, suitable for flange mounting to duct. Seal any and all gaps at frame joints to maintain airtight integrity of ductwork.

        1) Where flanged to duct mounting is not possible due to space restrictions or where Owner prefers access from inside duct, propose slip in style dampers on a case by case basis in damper submittal along with individual rationale for frame style selection.

    b. Provide extruded aluminum airfoil construction for dampers modulating outside and return airflow, isolating lead/lag blowers, those operating on systems with over 2" water column potential close off pressure, and those operating over 1500 fpm.

    c. Fasten aluminum frames with approved stainless steel fasteners, separated from dissimilar metal casing by dielectric gasketing.

    d. Damper blades not more than 8" in width.

    e. Mount blades on electroplated square or hexagonal steel shafting operating in stainless steel, bronze, or approved polymer sleeve bearings.

    f. Provide corrosion resistant linkage and actuator mounting compatible with the damper materials and service, concealed in the frame outside of the airstream for flanged to duct applications and mounted in the airstream for slip in construction.

    g. Provide parallel blade operation for all two position dampers, and opposed blade operation for modulating dampers, with exception of face and bypass dampers which shall be made up of two sections of parallel blade dampers with the blades of one damper opposed to the blades of the other for proper mixing.

    h. Dampers over 48 in. in length and height shall be made into multiple sections.

    i. Dampers shall be capable of sequencing as required.

j. Provide AMCA Standard 511 certified class 1A leakage dampers, with maximum leakage not exceeding 3 cfm per square foot at 1 inch water gage pressure differential, or 8 cfm per square foot at 4 inches water gage pressure differential when held in the closed position with a torque of no more than 6 inch pounds per sq. ft.

k. Temperature range shall be suitable for the intended service.

5. Galvanized Formed Blade Construction Dampers:

a. Frame of 16 gauge galvanized hat shaped channel.
b. Blades of single thickness 16 gauge interlocking formed galvanized steel.
c. Neoprene blade seals, and neoprene or compressible spring steel jamb seals.
d. Design make: Arrow Series 395.

6. Extruded Aluminum Airfoil Construction Dampers:

a. Frames and airfoil blades of extruded aluminum construction.
b. Extruded polymer dampers seals with airstream inflatable double edges, mechanically locked in extruded blade slots, and easily field replaceable.
c. Blades jamb seals compressible spring stainless steel.
d. Design make: Ruskin Model CD-50 or equal.

7. Thermally Broken Design Dampers shall be of similar construction to Extruded Aluminum Airfoil Construction Dampers above, with the following modifications:

a. Thermally broken frame with minimum three part extrusions separated by two structural urethane resin pockets.
b. Blades constructed of two part airfoil aluminum extrusions thermally isolated by insulation, with blade cores filled with expanded urethane insulation.
c. Dampers blade and jamb seals of extruded silicone and compressible spring stainless steel with leakage AMCA rated to -40 deg. F.
d. Twin damper blade seals, one on either side of the thermal break, enclosing an insulating airgap.
e. AMCA rated for energy efficiency with a minimum AMCA 500D Thermal Efficiency Ratio of 900%, and an assembly R value of 2 minimum.
f. Design make: Tamco series 9000 BF, Ruskin Model TED50BF, Greenheck ICD45, or equal, all with options as required to meet specification.

B. Valves:

1. Valve Types:

a. Ball valves – full port for two position on/off service, with characterizing disc for modulating service.
b. Butterfly valves - two-position on/off service or for use in modulating service where specifically called out as such on drawings.
c. Globe valves - modulating service.

2. Valve Bodies:

   a. Screwed bronze bodies (2" size and smaller).

   b. Flanged iron bodies (larger than 2" size).

   c. Ball valves shall be of two piece full port stainless steel ball and stem design similar to those described in SECTION 23 05 23 – "General Duty Valves for HVAC Piping" but with reinforced actuator duty stems, adapters, and electronic actuators.

   d. Butterfly valves shall be similar to those described in SECTION 23 05 23 – "General Duty Valves for HVAC Piping" with reinforced actuator duty stems, adapters, and actuators.

   e. Globe valves shall have characteristic type throttling plug, #316 stainless steel or Monel stem, and removable composition seats, tight closing to class 4 standard minimum. Provided with necessary features to operate in sequence with other valves or damper operators and adjustable throttling range.

   f. Two or three way as required.

   g. Designed for 125 psi operating pressure.

   h. Arrange to spring return to fail-safe position as called for, quiet operating.

3. Two position valves to be full line size unless otherwise indicated. Modulating water control valves shall be sized on the basis of the smaller of 15% of the total system pressure drop or 8 ft. of water column pressure drop, based on the system design flowrates. Include valve pressure drops in submittal for review. Tag each valve before delivery to project site with scheduled valve identification for location and service.

4. Provide valves and actuation so valves fail safe in normally open or closed positions as required to provide freeze, humidity, force, temperature, etc. protection. Fail position choice shall be submitted for review.

5. Select two-way modulating valves to have equal percentage characteristics.

C. Actuators:

1. Electronic actuators:

   a. Electronic actuators shall be motor driven with cast aluminum enclosure, with completely oil-immersed metal gear trains, sealed integral spiral spring return mechanism, force sensor safety stop, and shall have torque as needed to insure positive movement against system stall pressure. Furnish entire mechanism in housings designed for easy removal for service or adjustment.

   b. Size each actuator motor to operate with sufficient reserve power to provide smooth modulating or 2-position action as specified.

   c. Provide permanent split-capacitor, shaded pole, or synchronous motors with gear trains completely oil-immersed and sealed.

d. Equip motors for outdoor locations and for outside air intakes with "0 ring" gaskets designed to make motors completely weatherproof, and equip with internal heaters to permit normal operation at -40 deg F (-40 deg C).

e. All actuators for exterior use shall be electronic style and shall have NEMA 4 enclosures with a rain shield covering the valve stem and entire actuator housing.

f. Damper actuators shall be direct-coupled over the damper shaft, and shall be installed without connecting linkage where possible.

    1) Where linkages are required, for example with multiple section dampers or dampers where actuator must be installed in the air-stream, provide with linkage furnished by the damper manufacturer and designed for the actuator being used.

g. Ball and Butterfly valve actuators shall be direct-coupled over the valve shaft, installed without connecting linkage.

    1) Globe valve actuators shall have a rack and pinion linkage provided by the valve manufacturer and designed for the actuator being used.

h. The actuator shall have electronic overload and digital rotation sensing to prevent damage to the actuator through the entire rotation range of the actuator.

i. Actuators shall be capable of both clockwise and counter clockwise motion by changing mounting orientation.

j. Provide proportional actuators for modulating services that accept a 0 to 10 VDC or 4 to 20mA control input and provide a 2 to 10 VDC or a 4 to 20mA operating range. An actuator capable of accepting a pulse width modulated / floating point control signal and providing full proportional operation is only acceptable for hydronic valve services where there is no connection to outside air.

k. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC power shall not require more than 11VA.

l. All actuators shall have an external manual gear release and actuators with more than 60 in-lb torque capacity shall have a manual crank to allow manual positioning when the actuator is not powered.

m. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

n. Actuators shall be provided with a conduit fitting and minimum three foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

o. Actuators shall be UL Standard 873 listed and CSA Class 4813 02 certified as meeting correct safety requirements.

p. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuators rated torque and shall have a minimum 2-year manufacturer's warranty, starting from the date of installation.

q. Design make: TAC-I/A *DuraDrive* series and Belimo models as required by torque.

## 2.10 SAFETY DEVICES

A. Low Limit: Electric type with 20' long serpentine element, coldest foot sensitivity, with automatic reset and auxiliary contacts to the EMCS. Set for 37 deg. F for "freeze" protection and 55°F for fan discharge application.

B. Filter switches: Differential pressure type with adjustable set point, visual and audible trip indication, and auxiliary contacts to the EMCS.

## 2.11 MISCELLANEOUS DEVICES

A. Provide all necessary relays, controllers, accumulators, positioners, switches, solenoids, transformers, temperature sensors, and transducers for a complete system.

1. Locate these devices on local panel or enclosure adjacent to controlled equipment as required by codes and so as to facilitate service and maintenance, unless specified otherwise.

B. Relays:

1. Cube Type and Panel Mounted Relays:

a. SPDT or DPDT as required by application.
b. Cube type enclosure designed to mount on exterior of adjacent junction enclosure.
c. Track mount designed to mount on interior of panel or equipment adjacent junction enclosure.
d. Contact ratings: 10A resistive @ 120 - 277Vac, 1/3HP NO 120-240Vac, 10 million cycles minimum.
e. 10-30 Vac/dc to120 or 208/277 Vac coil as required.
f. LED status light.
g. Operating time 20mS max.
h. Operating conditions: -15 to 60 deg C, 0 to 95% rh.
i. CE and UL listed for plenum installation, RoHS compliant.
j. 5 year warranty.
k. Similar to Functional Devices, Inc., RIBU / RIBH series (cube type) and RIBMU series (track mount).

2. Combination Status Sensor / Relay / HOA Motor Control Devices:

a. SPDT or DPDT as required by application.
b. Enclosure designed to mount on exterior of adjacent junction enclosure.
c. Contact ratings: 1HP NO/NC 120Vac, 10 million cycles minimum.
d. Operating time 20mS max.

e. Integral HOA switch.
f. 10-30 Vac/dc to120 or 208/277 Vac coil as required.
g. Adjustable current sensing on switch 0.5A to 20A.
h. Current sensor capacity to 20A.
i. Digital switch output, rated 1A@30VAC/DC.
j. LED status light.
k. Hysteresis 10% max.
l. Operating conditions: -15 to 60 deg C, 0 to 95% rh.
m. CE and UL listed for plenum installation, RoHS compliant.
n. 5 year warranty.
o. Similar to Veris Hawkeye H548.

C. Wiring:

1. Controls power wiring: Provide wiring in accordance with requirements of Section 23 05 13 , Division 26, and the National Electrical Code.

2. Controls communications and data cabling:

a. Provide plenum rated cables, in full accordance with the requirements of Divisions 26 (Electrical) and 27 (Communication).

b. Provide cabling as recommended in writing by the controls manufacturer for optimized communications, similar to:

1) 22AWG single twisted pair, low capacitance (12.5pF/ft), shielded or unshielded plenum rated cable for low voltage communications.
2) 18AWG single twisted pair, low resistance (6mW/ft), shielded plenum rated cable.

3. Controls communications and data fiber optic cabling: Provide in accordance with the stricter of the requirements of Divisions 26, 27, and the written recommendations of the manufacturer of the equipment served.

4. Where additional wire to wire terminations are required beyond end device and controller termination strips, make connections using NEMA rated termination blocks with barrier isolated strip/screw or tube/screw connections, all labeled for current function. Flying splices not permitted.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which materials and methods are to be installed and notify Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in acceptable manner.

1. Installation indicates conditions are acceptable to Contractor as required to ensure requirements for applicable warranty or guarantee can be satisfied.

2. Electrical Wiring: Check all electrical wiring associated with equipment for compliance with specifications and correctness of connections. Correct wiring in event equipment or devices fail to function in specified manner, whether due to incorrect connections or improper information and wiring diagrams.

3. Verify that conditioned power supply is available to control units and operator workstation as required.

## 3.2 WORK INCLUDED

A. Provide all labor, materials, equipment, and services required for the complete removal of all existing controls components being replaced or upgraded as a part of this project or which serve equipment being removed as a part of this contract.

1. Insure that controls for areas outside of this contract's work remain intact and functional. Report any existing problems with functionality before demolition. New problem areas not otherwise a part of this scope that result from this demolition work: rebuild original functionality or upgrade to be included in the new controls.

B. Provide all labor, materials, equipment, and services required for the complete EMCS installation, including Related Work, as required in the Contract Documents. Provide all programming labor required for creating the specified sequences of operation and associated graphics. Include labor required for integrating any software and programming enhancements made both during construction and commissioning and during the warrantee period. Include labor for any programming modifications required due to special circumstances not adequately described in the written sequences of operations, as required to control systems operation as intended.

C. Provide all controls wiring required to connect devices furnished as part of or adjunctive to this EMCS regardless of the source of supply. Provide connections to Owner's LAN, WAN, telephone, and internet as required to perform controls work. Coordinate all fiber optic, telecommunications, and other electrical connections with Owner.

D. Provide power wiring for controls requiring connection to AC power. Control circuits to be 120 vac maximum. Install wiring in accordance with requirements of SECTION 23 05 13 - COMMON ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT, Division 26, and the National Electrical Code. Provide actuator power wiring to all automatic dampers including fire/smoke dampers. Coordinate required relays, etc.. with fire alarm system control wiring by Division 28.

E. Provide all necessary devices required for proper system operation, including special electrical switches, conditioned power supplies, transformers, disconnect switches, relays, circuit breaker protection, as required.

F. Provide all controllers, actuators, sensors, etc. as specified later herein, and as required to meet the specified sequence of operation.

G. Furnish all valves, control wells, and dampers to Contractor responsible for their installation, as specified and as required to meet the sequence of operation.

H. Provide interface connections from EMCS hardware to equipment starting circuits, alarms, etc.

I. The system shall include all accessory equipment and electrical wiring to fulfill the intent of this specification, including all control and communications components required to interface with the Owner's Ethernet LAN, forming a complete and interoperable system.

J. Each portion of the District EMCS system as described above shall include all gateways, translators, interpreters, software, programming, or other accessory devices as required to achieve BACnet communications over the LAN.

## 3.3 INSTALLATION

A. System shall be installed and adjusted by trained mechanics and technicians, with a demonstrated experience of not less than (5) years, in the installation, adjustment, and repair of temperature control systems.

B. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

D. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

## 3.4 SYSTEM COMPONENTS

A. Current Switches and Transducers: As required; install per manufacturer's written instructions.

1. Fixed setpoint digital output current switch: use only on fixed direct drive loads with no variability, under 0.5Kw, including small constant speed direct drive fans and pumps, and similar equipment.

2. Adjustable setpoint digital output current switch: use only on fixed but potentially variable loads including belt driven or coupled loads and similar conditions, under 0.5Kw. Adjust to sense broken belt or coupling or other loss of primary load while motor continues to run.

3. Analog Current Transducers: use on variable current / variable power loads and all loads above 0.5Kw including ECM fans, larger fans and pumps, and similar equipment.

    a. Where Variable Frequency Motor Controllers are used, monitor current / power and status through VFMC equipment interface to controls system.

4. Power Monitors: use on three phase loads without other comparable power use monitoring. Size and use for whole building loads as specified for Electrical Demand Monitoring and Control if integration to utility meter for comparable data is not available.

B. Electronic Duct Humidity Transmitter: As required; install per manufacturer's written instructions.

C. Temperature Sensors: Install per manufacturer's written instructions, in locations representative of the controlled spaces' temperature as required for proper control. Include proposed sensor locations in wiring diagram submittal.

1. Provide room temperature sensors for all spaces where thermostats are not specifically called for, as required to properly and individually control all building mechanical HVAC and domestic hot water equipment in accordance with the sequence of operation. For large spaces, provide at least one room sensor per 2000 square feet, in locations representative of the room's various exposures and internal loads.

2. Temperature Sensor with Guard: Provide sensor with guard (preferably S.S. wall plate sensor) wherever temperature sensor is called for in publicly accessed spaces similar to corridors, vestibules, lobbies, stairwells, cafeteria, gymnasium, auditorium, etc..

3. Duct and pipe temperature sensors: Provide as shown on the controls schematics and as required to properly control per the written sequence of operations.

4. Outdoor air sensors: Provide as required to accurately sense outdoor air conditions for proper economizer control, at least five separate locations facing each of East, West, North, and South, as well as a representative rooftop location.

D. Thermostats: Locate thermostats on walls symmetrical with adjacent items. Verify exact room location to avoid doors, fixed and portable equipment. Install to minimize damage. Do not install adjacent to lighting dimmers or other heat generating equipment. Include proposed thermostat locations in wiring diagram submittal.

1. Provide thermostats as specified and as required to properly and individually control all building mechanical HVAC equipment for all administrative offices, staff work and break rooms, classrooms, small group instruction rooms, large group instruction rooms, mechanical rooms, and spaces similar to these in function. Specifically not included in this list are corridors, vestibules, lobbies, stairwells, utility closets, and storage rooms.

2. Thermostat Guards: For bidding purposes, assume 10% of thermostats listed in 3.4.E.1 above will require guards – coordinate locations with Owner and Engineer during submittals. In addition to these and the multiple room sensors required by 3.4.D.1 above, provide single thermostat with protective guard for media center, cafeteria, gymnasium, and auditorium.

E. Automatic Dampers: Furnish dampers, tagged for proper location, (with multiple section damper linkages). Install per manufacturer's printed instructions. Adjust to close tightly. Allow for conduit sleeve or blank space for roof fan dampers.

F. Valves: Install with union or flanged connection. Locate close to apparatus controlled with pipe reducers and increasers located adjacent to valve. Locate, arrange, and pipe per installation diagram in an upright position (stem vertical).

G. Actuators: Install per manufacturer's printed instructions as to motor size and quantity, linkage arrangement, drive connection point. Where ducts or valves are insulated, set damper operators at least 2 in. away from equipment to allow for insulation.

H. Safety Devices:

1. Low Limit: Install on all equipment handling both water and any percentage of unheated outside air, including equipment in boiler rooms handling combustion air, serpentined on the discharge face of heating and/or cooling coils, or elsewhere as required for proper freeze protection, set at 37 deg F. Low limit trip shall report an alarm to the EMCS, which shall prevent the unit's fans from operating (not applicable to boiler burner fans), cause full flow of water in elements being protected, and fully close the outside air intake and exhaust air dampers until automatically reset (combustion air dampers shall not be closed when combustion is required for building heating). If some other sequence is required for proper freeze protection of special equipment or circumstances, provide this and detail in submittal.

2. High Limit: Install in the supply medium at the discharge of each fuel fired appliance. High limit trip shall report an alarm to the EMCS, which shall prevent the units burner from operating until manually reset.

3. Filter switches: Install across each bank of air filters in each air handling system.

## 3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

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 multiconductor 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.

## 3.6 SYSTEM SOFTWARE

A. Provide completely installed and ready for use.

B. System Configuration and Definition:

1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete, or modify the following:

   a. SCUs.
   b. OWSs.
   c. UCs.
   d. Points of any type, and all associated point parameters and using constants.
   e. Alarm reporting definition for each point.
   f. Control loops.
   g. Energy management applications.
   h. Time and calendar based programming.
   i. Totalization for every point.
   j. Historical data trending for every point.
   k. Custom control processes.
   l. All graphic displays, symbols, and cross references to point data.
   m. Dial-up telecommunication definition.
   n. All operator passwords.
   o. Alarm messages.

3. System Definition/control Sequence Documentation: All portions of system definition shall be self documenting to provide hard copy printouts of all configuration and application data. Control process and EMCS control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequence to be easily interpreted and modified at any time in the future.

4. Database Save/Restore/Back-Up: Back-up copies of all standalone EMCS panel databases shall be stored in at least one personal computer operator workstation, and a secure electronic copy of the original complete database setup shall be stored at the offices of the TCS, available for the Owner's use.

5. Continuous supervision of the integrity of all EMCS panel databases shall be provided. In the event that any EMCS panel on the network experiences a loss of its databases for any reason, the system shall automatically download a new copy of the respective database to restore proper operations. Database back-up/download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of an EMCS panel database.

## 3.7 GENERAL CONTROLS SYSTEM PROGRAMMING DESCRIPTION

A. Provide color graphic floor plan displays and system schematics detailing all mechanical and electrical systems as indicated in the sequence of operations, at least one for each system and piece of mechanical equipment, including air handling systems, chilled water systems, and heating systems. Create displays to represent logical grouping of system points or calculated data based upon building function, and mechanical system points which aid the operator in the analysis of the facility. The operator shall be able to view and control these systems via graphical and text-based displays and controls.

1. Provide access to the various system schematic and floor plan graphics via any and all of mouse driven graphical penetration scheme, menu selection, "file tree" organization, or text based commands.

a. Graphical menu penetration: locate and display systems graphics via a mouse driven procedure, designed and implemented to optimize performance analysis and speed alarm recognition. Five clicks maximum from whole district map to details of critical alarm via this route.

1) Whole District Map: Include each building shown as an active link; point and click to go to building. Display any building with (Owner defined, TCS implemented) alarms present as highlighted for rapid system review and diagnosis. Include at least three levels of alarm to facilitate prioritizing; each level shall be obvious and visually distinct. The most critical alarm in any building shall define the alarm level of that entire building in this graphic.

2) Main Building Display: Include a full floor key plan of each floor, broken into areas of detailed floor plans, with similar active point/click penetration scheme and highlighted alarm areas.

3) Detailed Floor Plans: Indicate the location of mechanical equipment (boilers, chiller, air handlers, duct and reheat / VAV systems, pumps and pumping systems, metering equip. etc.) and electrical equipment (switch gear, lighting, etc.) on the detailed floor plans. Highlight any systems when in alarm. Outline limits of each control zone (typically along walls, etc..) and provide active multicolored background for each zone. Zone background color shall change with space temperature deviation from setpoint, with a minimum of 8 background colors, colors to be distinct from alarm highlight colors.

4) System Specific Graphics: Provide pictorial schematically correct representations of each and every mechanical system controlled and/or monitored. Include all associated points, digital status, analog values, appropriate and/or significant calculated values, alarms, active adjustment of all user adjustable setpoints, links to all scheduling, trend logs, sequence of operations description, associated systems schematics in appropriate locations, etc. Include plain English descriptions of each active point / link shown. Include appropriate plain English warnings for alarms. Modify as required by Owner and Engineer during system review, start-up, and commissioning.

b. Menu and text based penetration: An operator request for information about a specific system shall cause the associated graphic display to be automatically selected and output on the viewing screen. The operator request may be entered via either the graphical menu penetration procedure or via a pull down directory tree style menu system with “specific building”, “specific mechanical room”, and “specific system” levels of identification. The pull down menu system shall cause the graphical menu system to be updated.

B. Graphic Representations

1. General: The program shall allow the operator to generate color graphics on-line using standard symbols selected from a standard library of symbols.

2. Provide customized graphics with dynamic point values and set points. Graphics shall include but not be limited to:

a. Each third party microprocessor controlled system with all points available.

b. Air Handling Equipment, air and water sides, zones, etc.

c. Floor Plans - The operator interface shall allow the user to access the various graphical schematics via a graphical penetration scheme of the floor plans. Minimum breakdown shall include:

1) Whole District map, showing all buildings.
2) Key plan of each building.
3) Floor plans of each building with zoom in capability.

C. Time Schedule Programs

1. The programs for the EMS shall schedule each system's operation on an hourly basis controlled through daily, weekly and/or monthly schedules. Schedules for each individual system, room or area shall be programmed and modified by the user on a calendar-like display at the OWS.

2. The programs shall store 60 months of schedules.

3. An internal time clock shall automatically compensate for daylight savings time and calendars generated by software shall automatically compensate for leap years.

D. Trend Logs:

1. Provide customized trend log reports with up to twenty variables per report for each HVAC system. Points shall be assignable at the OWS; coordinate desired points on each log with Owner during training and commissioning. Archive trended values on the system hard disk for future inquiry, with back up copies automatically prompted for and generated on removable media.

E. Alarm Points

1. Alarm all temperature inputs to the DDC system (space, return air, mixed air, discharge air, supply and return water, boiler and cooling systems) at the OWS if the temperature is out of range 10 deg. F (adj.) above or below setpoint.

2. Monitor fan status with current sensing devices or differential pressure switch. If the fan is scheduled to run and the status is not proven, generate an alarm condition shown at the OWS.

3. Monitor pump status with current sensing devices. If the pump is scheduled to run and the status is not proven, generate an alarm condition at the OWS.

4. Monitor all alarm points of any stand alone controllers such as boiler burner controls, chiller or condensing unit controls, etc.., and generate an appropriately annunciated alarm condition at the OWS.

5. For all alarms, provide appropriate text and graphical annunciation to facilitate ease of understanding of source and location of problem. Coordinate annunciation with Engineer, equipment manufacturers, and Owner's representatives.

F. Optimum Start and Stop Program

1. Bring the building from unoccupied control mode through a warmup / cooldown mode into occupied mode through a controlled optimum start program. Gradually change space temperature requirements from unoccupied to occupied setpoints over a predetermined time to not only bring the building to required temperature but also soft start building mechanical equipment.

2. Include warm-up/cool-down mode between unoccupied and occupied periods such that the temperature reaches occupied setpoint before occupied ventilation begins.

3. Each system shall have an independent modular program.

4. Minimize the total energy consumption during daily start-up and shut-down of each heating/cooling system via optimized timing and adjustment.

5. Compare the outside air temperature to space temperature, required setpoints, and historical startup and shut-down data to calculate optimized start and stop times for each system.

6. Adjust the timing for each system to bring its respective zone to occupied setpoint at the time of occupied mode start and to shut-down its respective zone as early as possible without letting the temperature drift out of the specified comfort range..

7. The optimum start / stop program shall be adjustable to the rate structure of the local energy company.

8. Incorporate an enhanced ventilation mode in the Optimum Start Program

G. Optimum Stop Program

1. Each system shall have independent modular program.

2. The program shall minimize the total energy consumption during daily shut-down of each heating/cooling system.
3. A control algorithm shall compare the outside air temperature to space temperature to calculate a stop time for each air handling system.
4. The stop time for each system shall shut-down its respective zone as early as possible without letting the temperature drift out of the specified comfort range.
5. Minimum outside air ventilation shall be maintained where required by occupied status requirements of space served.

H. Smoke Dampers And Fire/Fan Shut Down

1. When fire alarm condition is initiated, the fire alarm system shall directly cause all fans 1000 cfm and larger to shut down and shall provide a signal to the EMCS to note fire alarm condition.

2. When fire alarm condition signal is received from the fire alarm system, initiate the following sequence:

a. Cause all building fans 1000 cfm and larger to shut down. This is in addition to the direct shutdown caused by the fire alarm system.

1) Allow variable speed drives to ramp down and ramp up on restart.

b. Cause all smoke dampers and fire-smoke dampers to close and remain closed for the duration of the alarm condition. Delay closing smoke dampers until associated fan system has completely stopped (10 sec. Maximum).

c. Do not permit unrelated HVAC equipment (heating valves, pumps, etc..) in building to lose control.

d. Provide separate control wiring, connections to fire alarm system, all required smoke dampers, etc.., as required to accomplish the required sequence.

e. Upon termination of the fire alarm condition as indicated by a signal from the fire alarm system, cause all automatic fire/smoke dampers to open and prove open, then return all affected fans to their normally scheduled operation using the demand limiting staggered start algorithm.

I. Day/night Setback

1. The day/night setback will consist of lowering the space heating setpoint and raising the space cooling setpoint during the unoccupied mode, thereby reducing the heating and cooling energy requirements. The occupied and unoccupied areas will be specified by the owner and will be coordinated with the control system.

J. Economizer Cooling Cycle

1. The controls shall incorporate an enthalpy logic center with outdoor and return air temperature and humidity sensors that shall maximize the use of outdoor air for cooling before the mechanical cooling is energized and during operation through comparison of outdoor and return air enthalpy as follows. Note that multiple outdoor temperature conditions will be present at different outside air intake locations, and as such a comparable number of outside air sensors are required. Some mechanical systems may share a single outdoor air enthalpy center, for example adjacent UVs each facing east, providing the outdoor air conditions can be demonstrated to be virtually identical from an energy management perspective. Provide at minimum East, West, South, North, and Rooftop outdoor air sensors.

2. When the outdoor air enthalpy is less than the return air enthalpy during cooling mode, the logic circuitry shall cause the outdoor and return air dampers to modulate to the balanced outdoor air position that satisfies the critical space temperature transmitter set point before opening the system chilled water cooling valve.

3. If the outdoor air enthalpy is less than the return air enthalpy and the critical space temperature transmitter set point cannot be satisfied with 100% outside air, then the system shall circulate 100% outside air and the cooling water valve shall modulate open to satisfy the zone temperature requirements.

4. If the enthalpy sensors indicate that the return air has lower enthalpy than the outdoor air, then the system shall revert to normal cooling mode.

5. Upon a call for cooling to maintain the night setback temperature, only the economizer mode shall be operational. The chilled water control valve shall not be opened, and upon satisfying the space temperature transmitter night setback set point, the system shall revert to the normal unoccupied mode.

K. Maintenance Management: Continuously totalize run hours for equipment controlled and/or monitored for use by the maintenance management program.

L. Equipment Scheduling

1. Equipment shall be capable of 7 days, 24 hours schedules with separate holiday hours.
2. There shall be capability for five different holiday schedules which can be selected from the occupancy schedule graphic.
3. Holidays shall be programmed so that they shall need a minimum of manual adjustment year to year and can easily be modified at front end if necessary.
4. All schedule programming shall reside in local controllers, but shall be configurable from the front end.

M. Coil Freeze Protection.

1. Heating and cooling coils and any other equipment provided as a part of this project which are circulating water (not required for glycol coils) or are otherwise subject to water freeze damage, subject to the following, that have any percentage of unheated outside air entering them, shall have coil freeze protection.

2. Mixed outside and return air and the preconditioned discharge air from air to air energy recovery units shall be considered unheated for this purpose.

3. The first stage of coil freeze protection shall incorporate analog input temperature sensing at the expected freeze location. Sensing devices may be immersion style return water temperature sensor piped as close as practical to the outlet of the coil (within the rooftop unit if applicable), surface temperature sensors on the coil surface at the expected freeze location, or other comparable devices approved as applicable to the circumstances. Include details of freeze protection scheme for all such equipment in submittal. When the sensed temperature is above 60ºF (adj.), the coil control valve shall be under space temperature control. If at any time the expected freeze location sensed temperature drops below 60ºF (adj.), the control valve shall temporarily open to raise that coil's return water temperature to above 80ºF (adj.), and the EMCS shall report an alarm to the OWS

4. The second stage of coil freeze protection shall be the low limit freeze stat air temperature sensors with the sequence defined under safeties, above.

## 3.8 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, and to assist in field testing. 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 unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. 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 temperature instruments and material and length of sensing elements.

5. Check control valves. Verify that they are in correct direction.

6. 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.

## 3.9 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. 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.

6. 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.

7. 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.

8. Provide diagnostic and test instruments for calibration and adjustment of system.

9. 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.

## 3.10 SYSTEM TESTING AND COMMISSIONING

A. Test complete control system for control device operation prior to the systems acceptance. Demonstrate complete sequence of operations to Architect's and Owner's representatives.

1. Verify operation of system inputs and outputs, control loops and/or software programming, timing functions, operator entered constants, facilities management functions, etc., and observe that they perform their intended functions. Generate check out data sheets for each system so verified.

2. Field verify analog input calibration, analog output operation, digital input function, digital output operation, and coordination of system inputs and outputs between system graphics and field devices for schematic accuracy. Coordinate device testing with Testing and Balancing Agency – refer to section 23 05 93 – Testing, Adjusting, and Balancing for HVAC for additional information. Generate check list of all devices, keyed with descriptive locations and functions, along with complete calibration, testing, and coordination data, certified by Contractor and TAB agency.

3. Provide complete values and points logs, printed with hourly values for one week, demonstrating correct control functions and programming.

B. When above procedure has been completed and control systems are operating satisfactorily, produce and submit a report of entire systems performance for review, including all data described above. Submit three copies to the Architect's Representative advising them that the control system is 100% complete and operates in accordance with the Contract Documents.

## 3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 09 00

# SECTION 23 21 13 - HYDRONIC PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes pipe and fitting materials, special-duty hydronic systems fittings, equipment, valves, and specialties, and joining methods for the following:

1. Hydronic Systems piping.
2. Air-vent piping.

### 1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Steel and Copper Hydronic Piping: 125psig at 250 deg F.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Above Grade Piping
2. Pipe Fittings.
3. Dielectric Fittings.
4. Specialty Valves.
5. Air and Pressure Control.
6. Pressure Control
7. Special Duty Hydronic Components.

B. Shop Drawings: Include in coordination drawings details of the piping layout showing proposed piping routing including locations of offsets, fittings, elevations with drain and vent fittings, pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Provide enlarged details of congested areas, custom anchor fabrication, and other details as required to clearly delineate the proposed construction.

C. Welding Quality Control Submittals

1. When welded or brazed pipe work is required or proposed as a part of this project, submit following for approval before beginning any welding or brazing work:

a. Welding and Brazing Procedure Qualification: Prepare and submit for approval welding and brazing procedure qualification specification qualifying all proposed procedures as specified in Quality Assurance below with copies of all back-up data.

b. Welders' and Brazers' Certification: Submit for approval certification that each proposed welder, welding operator, brazer, or brazing operator has been qualified in all procedures proposed for that worker as specified in Quality Assurance below with copies of all back-up data.

D. Qualification Data: For Mechanical Grooved and Pressure Sealed Joint Installers.

## 1.5 CLOSEOUT SUBMITTALS

A. Field quality-control test reports.
B. 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. Regulatory Requirements: Comply with all applicable sections of the following:

1. ANSI / ASME B 31.9: "Building Services Piping".
2. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
3. New York State Labor Department Industrial Code Rule No. 4 (cited as 12 NYCRR4)
4. New York State Labor Department Industrial Code Rule No. 14 (cited as 12 NYCRR14).
5. Building Code of New York State.
6. ANSI / ASHRAE 15 "Standard Safety Code for Mechanical Refrigeration".
7. ASME label on all pressure vessels and safety valves.
8. ANSI / ASME B31 – "Code for Pressure Piping".

B. Installer Qualifications:

C. Welded Support Work Quality Control:

1. Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Welded Piping Work Quality Control:

1. Welding and Brazing Procedure Qualifications: Qualify any welding or brazing procedure to be used on this Project in accordance with ASME "Boiler and Pressure Vessel Code", Section IX. Qualification may by made by technically competent group or agency (subject to approval) meeting the following conditions:

    a. Group or agency qualifying the procedure meets all procedure qualification requirements of ASME "Boiler and Pressure Vessel Code", Section IX.

    b. Contractor accepts full responsibility for procedure qualified.

    c. Contractor has qualified at least one welder or welding operator using procedure qualified and provides record of qualification.

    d. Contractor accepts full responsibility for qualified procedures by signing related qualification records with procedure and performance qualifications including all dates, results, and associated data.

2. Welders' and Brazers' Qualifications: Ensure that all welders, welding operators, brazers, or brazing operators employed for this project are qualified for all welding and brazing procedures, proposed as part of this Project, in accordance with ASME "Boiler and Pressure Vessel Code", Section IX. Qualification by previous employer or technically competent group or agency (subject to approval) may be acceptable if following information is included:

    a. Documentation that the previous qualification was for essentially the same procedures proposed and was in full accordance with ASME "Boiler and Pressure Vessel Code", Section IX.

    b. Copy of performance qualification testing record showing who qualified the worker, date of qualification, and work history record showing continuous performance to maintain qualification.

3. Weld and Braze Qualification Records: Maintain and sign certified records of approved procedures used and approved qualified workers employed for welded and brazed joints performed as a part of Contract Work. Ensure all building services piping welding and brazing work can be traced to a specific procedure and welder.

4. Inspection and Examination by Owner, Remedy by Contractor: Owner reserves right to examine, inspect, and test all piping using visual, radiographic, or other recognized testing methods to determine compliance with specified quality control requirements and requirements of applicable regulatory agencies.

    a. Cost of Owner's testing of acceptable installation provided at Owner's expense
    b. Repair piping installations not passing Owner's quality inspection testing using approved method or replace at no additional cost.
    c. Cost of initial testing of piping not conforming to specified requirements and any retesting of repairs or replacement work shall be deducted from Contract Sum.

E. 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.

## PART 2 - PRODUCTS

### 2.1 COPPER TUBE AND FITTINGS

A. Refer to Part 3 for Piping Applications Article.

B. 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. Anvil International, Inc.
2. Cerro Flow Products, Inc.
3. Mueller Industries, Inc.
4. S. P. Fittings; a division of Star Pipe Products.
5. Viega LLC
6. Victaulic Company of America.

C. Copper Tubing: ASTM B 88, Annealed or Drawn Temper, Types M, L, and K.

D. Copper Tube Fittings:

1. Solder Fittings

a. Tees, Elbows, Reducers, Adapters: ANSI B16.22 streamlined pattern wrought copper or ANSI B16.18 cast bronze; solder end connections; ASTM B62.
b. Unions: Solder type, cast bronze, ground joint, Class 150.
c. Cast Bronze Flanges: ANSI B16.24 Class 150 solder connection flanges, raised ground face, ANSI pattern drilled and spot faced bolt holes.

2. Pressure-Seal Fittings:

a. Housing: Copper conforming to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117.
b. Sealing elements: EPDM, factory installed by fitting manufacturer.
c. Leakage path designed into un-pressed fittings assuring readily visible leakage of system liquids past the sealing element of any un-pressed connection.
d. Tools: Manufacturer's special tools that compress fittings and effect pressure seal.
e. Minimum 200-psig working-pressure rating at 250 deg F.

3. Mechanically Formed Tee Option:

a. Outlet: formed by proprietary rotating tool expanding drilled side hole of main tube into precision collar.

b. Branch Inlet: Formed by proprietary tool that radius clips tube ends matching circumference of main tube, and dimples indicating correct insertion depth and orientation that remain visible after brazing.

c. Connection: Brazed joint, stronger than original main tube, with smoothly radiused branch entry and 0% flow obstruction.

## 2.2 STEEL PIPE AND FITTINGS

A. Refer to Part 3 for Piping Applications Article.

B. Steel Pipe: ASTM A53-S , A53-E, or A106 Schedule 40 or 80, seamless (type S) or electric-resistance welded (type ERW), Grade B, black or ASTM A123 and A153 galvanized steel pipe, plain or threaded ends.

C. Threaded Fittings:

1. Pipe threads in accordance with ANSI/ASME B1.20.1 National Pipe Thread taper (NPT) standards.
2. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.
3. Unions: ASME B16.39 malleable iron, threaded, Class 150 or higher, ground joint bronze to iron seat.
4. Cast-Iron Fittings: ASME B16.4; Class 125 or higher.
5. Malleable-Iron Fittings: ASME B16.3, Class 150 or higher.
6. Flanges: Cast Iron ASME B16.1 Class 125 or higher, raised ground face, ANSI pattern drilled and spot faced bolt holes.

D. Welded Steel Fittings: ASTM A 234/A 234M or A106 seamless forged steel.

1. ASME/ANSI B16.9 pattern with ASME/ANSI B16.25 beveled butt weld ends, wall thickness to match adjoining pipe.

   a. Long radius pattern unless space restrictions prohibit, then short radius allowed.

2. ASME B16.11 socket weld class 2000.

3. Flanges: ANSI B16.5 Class 150 or higher, butt weld neck type, raised ground face, ANSI pattern drilled and spot faced bolt holes.

4. Where branch connections are two or more sizes smaller than main size, "weldolets" or "threadolets" are acceptable.

5. Fabricate custom bend angle fittings by removing material from standard butt weld type fittings at the appropriate angle and recreating the original ASME B16.25 weld configuration chamfer.

   a. Shop or site-weld weld/groove adapter nipples to custom angle fitting where applicable to create custom angle grooved mechanical fittings.

## 2.3 JOINING MATERIALS

A. Flanges:

1. Gasket Materials:

a. ASME B16.21, nonmetallic, flat, asbestos free, suitable for chemical, pressure, and thermal conditions of system.
b. 1/8-inch maximum thickness unless thickness or specific material is indicated.
c. Full or narrow face pattern to fit flanges.

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

3. Provide dielectric kit for flanges joining dis-similar piping materials.

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

B. Solder Filler Metals: Use solder conforming to ASTM B 32-95; alloy grades Sn96, Sn95, Sn94, E, AM, WS; lead free alloys with maximum lead content of 0.1percent by weight, minimum solidus temperature of 430 deg. F, and approved for use with potable water. Higher lead content solder not acceptable. Include water-flushable flux according to ASTM B 813.

C. Brazing Filler Metals: Select brazing filler metals compatible with piping to be joined:

1. AWS A5.8 BCuP Series, copper-phosphorus alloys for joining copper with copper only.

2. AWS A5.8 BAg series, cadmium free silver bearing alloys for joining dis-similar metals including copper with any brass, bronze, steel, or stainless steels, or other dis-similar brazeable materials.

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

## 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, designed to join dis-similar metallic piping materials with dis-similar metals separated by dielectric material in a configuration to minimize galvanic corrosion of the less noble piping material.

B. 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. Advance Products & Systems, Inc.
2. Capitol Manufacturing Company.
3. Central Plastics Company.
4. Elster-Perfection Corporation.
5. Hart Industries International, Inc.
6. Lochinvar Corporation.

7. Pipeline Seal and Insulator, Inc.
8. Precision Plumbing Products, Inc.
9. Sioux Chief Manufacturing Company, Inc.
10. Victaulic Company of America.
11. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
12. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

C. All Materials: Suitable for system fluid, pressure, and temperature.

D. Dielectric Nipples:

1. Galvanized steel nipple with insert of noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

E. Dielectric Couplings:

1. Galvanized-steel coupling with insert of noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Unions:

1. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

G. Dielectric-Flange Kits:

1. Flange assembly kit for field assembly. Include full-face or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, steel backing washers, and appropriately sized bolts and heavy pattern nuts. Provide bolts of length as required for full engagement in nuts, of higher strength if undersized for bolt sleeves as required to maintain system working pressure.

## 2.5 VALVES

A. Isolation, Check, Balancing, Vent, and Drain Valves: Comply with requirements specified in Section 23 05 23 -General-Duty Valves for HVAC Piping
B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00 - Instrumentation and Control for HVAC.

## 2.6 HYDRONIC PIPING ACCESSORIES

A. Pipe Sleeves:

1. Sleeve 6-Inches Diameter and Smaller: Schedule 40 galvanized, welded steel pipe, ASTM A53, Grade A.

2. Sleeves Larger than 6-inches: Galvanized sheet metal, 10 gauge, round tube with welded longitudinal joint.

3. Sleeves Installed In Masonry Or Cold Formed Metal Framing/Gypsum Board Construction: Galvanized sheet metal, 20 gauge, round tube with welded longitudinal joint.

B. Escutcheons: Chrome plated, stamped steel, hinged, split-ring escutcheons, with setscrew. Inside diameter closely fits pipe outside diameter or outside diameter of pipe insulation where piping is insulated. Outside diameter completely covers opening in floor, wall, or ceiling.

1. Manufacturer: Manufacturers offering acceptable products include Grinnell.

C. Mechanical Sleeve Seals: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to fill annular space continuously between pipe and sleeve. Connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

1. Manufacturer: Manufacturers offering acceptable products include Thunderline Corp.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

A. Closed Loop Hydronic Piping (heating or dual temperature), aboveground, NPS 2 and smaller:

1. Type L drawn-temper copper tubing with wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe with welded, threaded, or mechanical grooved fittings and joints.

B. Closed Loop Hydronic Piping (heating or dual temperature), aboveground, NPS 2-1/2 and larger:

1. Schedule 40 steel pipe with welded or mechanical grooved fittings and joints.

C. Air-Conditioning Condensate Gravity Drain Piping:

1. Type M or L, drawn-temper copper tubing, wrought-copper drain fittings, and soldered joints.

D. 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.

## 3.2 PIPING INSTALLATIONS

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

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

C. Install piping in concealed locations except in equipment rooms and service areas, unless otherwise indicated on drawings: install in walls, pipe chases, utility spaces, above ceilings, etc.

D. Install piping orthogonal to building walls as possible within constraints required for sloped drainage, non-orthogonal building construction, etc. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install fittings for changes in direction and branch connections, unless otherwise specified.

1. Branches two or more sizes smaller than main may be weld-o-let welded to steel pipe and brazed to copper using listed mechanically formed outlets similar to “T-drill”.

2. Minor offsets in copper fin-tube piping required to segment enclosures along curved exterior walls may be created by smooth bends in annealed type L or K copper tube. Do not bend fin element.

3. Mitered elbows, "shaped" nipples, and job fabricated reductions are not acceptable.

4. Where corridors or other general construction meets at angles other than standard pipe fitting angles, provide custom bend angle elbows to match general construction and maintain piping orthogonal to building.

F. Install piping so as to provide for positive drainage and air elimination.

1. Install straight piping free of sags and bends. Do not install bent piping – remove from site.

2. Install gravity drain lines at uniform slope down in direction of flow. Maintain maximum slope feasible up to one quarter inch rise per foot of run, but not less than 1% (approximately one eight inch per foot). Where height restrictions do not allow for minimum required slope, provide for pumped condensate removal as shown.

3. Install pressurized pumped flow piping at a uniform grade of 0.2 percent upward in direction of flow or at otherwise indicated slopes.

4. Avoid local high and low points where possible.

5. Install branch connections out the top of mains to serve equipment above mains, and out the bottom of mains to serve equipment below, or otherwise as required to provide drainage and venting with a minimum of drain and vent fittings.

6. Provide eccentric pipe size reducers and increasers, installed so as to allow for both positive drainage and air elimination. In general, where piping is sloped up in direction of flow, reduce pipe sizes with level side up and increase pipe sizes with level side down.

G. Install piping allowing for proper servicing of hydronic systems.

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

2. Install piping and specialties with sufficient clearance to allow application of specified insulation.

3. Install valves with sufficient clearance and orientation to permit both ease of operation and servicing.

4. Install dis-assemble able unions, flanges, or mechanical joints on equipment side of isolation valve**,** as required to remove and service all serviceable components without system drain-down or cutting piping. Install unions and flanges in piping,.

a. Provide unions for NPS 2 and smaller, flanges for NPS 2-1/2" and larger.

b. Install adjacent to control valves, at final connections of equipment, as required to adjust threaded pipe joints after fixed (non-rotatable) joints are made, and elsewhere as indicated.

c. Install out of the line of coil pull, tube bundle removal access space, etc.

d. Install so sensor wires, thermometers, gauges, etc., need not be rotated, removed, or disconnected to service equipment.

e. Install within two feet of control valves with no elbows between valve and union as required for ease of replacement.

f. One dis-assemble able fitting may be used for two components (ex., both control valve and equipment service) if they are separated by no soldered, brazed, or welded elbows and no more than three feet of pipe.

H. Install sleeves for piping penetrations of walls, ceilings, and floors.

I. Install escutcheons for exposed piping penetrations of walls, ceilings, and floors.

J. Install sleeve seals for piping penetrations of concrete walls and slabs.

## 3.3 PIPE JOINT CONSTRUCTION

A. General Pipe Joint Construction:

1. Cut all pipe ends square.
2. Ream ends of pipes and tubes removing burrs past original pipe wall to restore full pipe ID.

3. Remove scale, slag, dirt, and debris from both inside and outside of piping and fittings before assembly.
4. Remake leaking joints using new materials.

B. Threaded Joints:

1. Provide threaded pipe ends in conformance with ANSI B1.20.1, tapered pipe thread standards

2. Cut threads full and clean using sharp cutting oil flooded dies.

3. Note internal length of threads in fittings or valve ends and proximity of internal seat or wall to determine pipe threading and align threads at point of assembly.

4. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified) and assemble joint “wrench-tight” with paired wrenches, one wrench on adjacent pipe and one wrench on valve end where pipe is threaded.

5. Damaged Threads: Do not use pipe or fittings with torn, corroded or damaged threads.

6. Do not use portions of pipe where weld opens during cutting or threading operations.

C. Soldered Joints:

1. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook,"

2. Square cut tubing to correct length required to fill sockets.

3. Ream ends and clean surfaces of oils, grease, and oxidation to bright finish with fine sand cloth, cleaning pads, or special wire brush.

4. Apply thin film of solder flux to both surfaces to be joined. Do not clean, flux and assemble joint more than 3 hours before soldering, and do not use acid core, paste type solder, or solder flux combinations.

5. Remove heat-sensitive portions of components prior to soldering. Provide wet rag strip heat sink wrapped around stem and seat of valves and protect all components for soldering heat damage. Replace any components with any evidence of heat damage.

6. Heat joint uniformly and rapidly and fill completely with solder while minimizing external and internal over-soldered dripping.

7. Disassemble joints for inspection of solder penetration as directed. Remake faulty joints at no additional cost.

D. Brazed Joints:

1. Comply with the procedures contained in AWS "Brazing Manual", using qualified processes and brazing operators according to Part 1 "Quality Assurance" Article.
2. Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.

3. Fill the pipe and fittings with an inert gas (i.e. nitrogen or carbon dioxide) during brazing to prevent formation of scale.
4. Heat joints using oxyacetylene torch. Heat to proper and uniform temperature.
5. Completely fill sockets with braze materials, and make neat fillets on butt joints.

E. Welded Joints:

1. Comply with the requirements of ASME Code B31.9 - "Building Services Piping", ASME B16.25, and AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

2. Machine-chamfer all pipe ends for butt welded joints.

3. Remove cutting beads and do not allow welding beads to form.

F. Pressure-Sealed Joints:

1. Make copper and copper alloy press connections in accordance with the manufacturer's installation instructions.
2. Fully insert the tubing into the fitting with a visible mark on the tubing showing proper insertion. Align the tubing as required.
3. Check the fitting alignment against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. Leave insertion marks visible on pipe after assembly.
4. Press the joints using the tool(s) approved by the joint manufacturer in a manner to assure tubing remains properly aligned.
5. Remove and replace misaligned, kinked, or otherwise damaged tubing installations. .

## 3.4 HYDRONIC SPECIALTIES INSTALLATION

A. At each system local or global low point, both in piping and heat transfer elements, and as required for complete system drainage, install drain consisting of a tee fitting and drain valve as described in Section 23 05 23 – General Duty Valves for HVAC Piping.

B. At each system local or global high point, both in piping and heat transfer elements, at the end of each horizontal run before a drop in elevation, and elsewhere as required for complete and serviceable venting of system air, install vent consisting of a tee fitting and air vent as described in Section 23 05 23 – General Duty Valves for HVAC Piping.

C. Install AC condensate termination strainers where AC condensate drips to any exterior point of indirect waste disposal.

D. Install expansion compensation as shown on drawings and in all straight piping runs eighty (80) feet long and longer, at least one (1) expansion loop per one hundred twenty (120) feet of straight run. Install anchors and pipe alignment guides for each expansion loop. Install expansion compensation, anchors, and pipe alignment guides as specified in Sections 23 05 29 – Hangers and Supports for HVAC Components and Section 23 05 43 – Mechanical Vibration and Movement Control.

E. Install all components of Energy Management and Control System (EMCS) into hydronic systems as required for complete EMCS installation and as required by this section maintaining integrity if hydronic systems. Coordinate all locations and quantities with contractor responsible for the EMCS – refer to Section 23 09 00 – Instrumentation and Control for HVAC.

1. Install control valves in accessible locations close to connected equipment or as otherwise shown, with dis-assemble able connections.
2. Install wells for pressure, temperature, and other sensors as shown on details and as called for by the sequence of operations.

F. Install ports and wells for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

G. Install pressure / temperature test ports (P/T plugs) at the supply and return of every heat transfer element, and as otherwise called for on drawings.

## 3.5 VALVE APPLICATIONS

A. Install General Duty Valves (isolation valves, check valves, balancing valves, air vent valves, and drain valves) as specified in Section 23 05 23 – General Duty Valves for HVAC Piping.

## 3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 23 05 29 "Hangers and Supports for HVAC Components". Comply with the following requirements for maximum spacing of supports.

B. Sound, vibration, and movement control is specified in Section 23 05 43 – Mechanical Vibration and Movement Control.

## 3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size supply and return piping run-outs to equipment connections same as shown on the drawings. Where connecting to existing piping run-outs, use same size as existing unless shown otherwise. Transition to equipment connection size close to equipment. If equipment connection size is smaller than piping shown, transition to piping size shown immediately with no elbows (except reducer elbows) or other fittings closer to the equipment than the required transition fitting.

B. Provide for thermal movement of piping adjacent to terminal equipment, using flexible hose connections, swing joints, etc. Refer to Section 23 05 43 – Mechanical Vibration and Movement Control for details.

## 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.

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. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. 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."

4. After hydrostatic test pressure has been applied for at least 10 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.

5. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. 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).
3. Set temperature controls so all coils are calling for full flow.
4. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.

END OF SECTION 23 21 13

# SECTION 23 23 00 - REFRIGERANT PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

### 1.3 PERFORMANCE REQUIREMENTS

A. 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.

### 1.4 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of refrigerant, piping, valve, and refrigerant piping specialty proposed. Include pressure drop, based on manufacturer's test data, for the following:

1. Refrigerant.
2. Thermostatic expansion valves.
3. Solenoid valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

### 1.6 CLOSEOUT SUBMITTALS

A. Field quality-control test reports.
B. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

## 1.7 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

## 1.8 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.

## 1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

# PART 2 - PRODUCTS

## 2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L**,** ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. 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 deg F.

## 2.2 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 deg F.

B. 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.

C. 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 deg F .
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig .

D. 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 deg F .

E. 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 deg F.

F. 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 deg F.

## 2.3 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

# PART 3 - EXECUTION

## 3.1 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 joints.

B. Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

## 3.2 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. 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.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

E. 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.

F. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Thermostatic expansion valves.
2. Compressor.

G. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor, if not provided as part of installed equipment manufacturer.

H. Install flexible connectors at compressors.

## 3.3 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.

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. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

L. 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.

M. 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.

N. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23.

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23.

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors.

## 3.4 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. 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.

## 3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in specification Section 23 05 29 - Hangers and Supports for HVAC Components.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. 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.

## 3.6 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.
    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.

## 3.7 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.

## 3.8 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.

END OF SECTION 23 23 00

# SECTION 23 29 00 – VARIABLE FREQUENCY MOTOR CONTROLLERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFCs (variously referred to as VFC, ASD, VSD, or VFD), rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1. "Micro-drive": VFC for use with motors of 1HP or less (unless scheduled otherwise), capable of and designed for driving three phase motors with single phase or three phase input line power, as required.
2. "General Purpose" VFC for use with motors > 1HP (unless scheduled otherwise)

### 1.3 DEFINITIONS

A. ASD: Adjustable Speed Drive, same as VFC.
B. BAS: Building automation system
C. CPT: Control power transformer.
D. EMI: Electromagnetic interference.
E. EMC: Electromagnetic Compliance.
F. IGBT: Insulated-gate bipolar transistor.
G. LAN: Local area network.
H. LED: Light-emitting diode.
I. MCP: Motor-circuit protector.
J. NC: Normally closed.
K. NO: Normally open.
L. OCPD: Overcurrent protective device.
M. Output: Variable frequency output power and wiring between the VFC and the load (motor).
N. PCC: Point of common coupling.
O. PID: Control action, proportional plus integral plus derivative.
P. Power: source electrical power input wiring to the VFC.
Q. PWM: Pulse-width modulated.
R. RFI: Radio-frequency interference.
S. Signal: Remote generated electrical signal causing controlled variation in VFC output.
T. TDD: Total demand (harmonic current) distortion.
U. THD(V): Total harmonic voltage demand.
V. VFC: Variable-frequency motor controller.
W. VFD: Variable Frequency Drive, same as VFC.
X. VSD: Variable Speed Drive, same as VFC.

## 1.4 PERFORMANCE REQUIREMENTS

A. Design and Performance Requirements

1. Designed to convert 60 Hz input power to adjustable frequency output power with constant and/or variable volts/Hz ratio output power. Output frequency and drive voltage adjustable determined by design parameters of driven motor.

2. Capable of operating any standard squirrel cage induction motor with load rating within capacity of adjustable speed drive. Allows substitution of standard motor in field without requiring modification of adjustable speed drive.

3. Designed and manufactured in accordance with applicable current NEMA and IEEE recommendations and designed for installation per NEC. Includes equipment with UL and CSA approval as applicable.

4. Suitable for installation in altitudes up to 3300 ft with ambient temperature range from 32 deg F to 104 deg F

5. Designed with dedicated variable torque design for specified use with centrifugal loads.

6. “Micro-Drive” includes all of above features plus:

   a. Capable of and designed for converting single-phase input to three phase output.

7. “General Purpose” Drive includes all of above features plus:

   a. Suitable to serve as starter and disconnect.

   b. Designed with surface-mount construction regulator circuits.

   c. Provided with UL-listed electrical components in basic ASD, including but not limited to contactors, overload relays, pushbuttons, pilot devices, and other control devices.

## 1.5 SUBMITTALS

A. Procedural Requirements: Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.

B. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories. Include output cabling.

C. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

    a. Each installed unit's type and details.
    b. Factory-installed devices.
    c. Enclosure types and details.
    d. Nameplate legends.
    e. Short-circuit current (withstand) rating of enclosed unit.
    f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
    g. Specified modifications.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

## 1.6 INFORMATIONAL SUBMITTALS

A. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification and IEEE519 Guidelines for both Current and Voltage Distortion in a distribution system; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC to specified levels. Include measurements taken on the line side of the main distribution transformer coordinated with local electrical utility, or if not possible from the load or low voltage side of that same transformer.

B. Qualification Data: For qualified testing agency.

C. Product Certificates: For each VFC, from manufacturer.

D. Source quality-control reports.

## 1.7 CLOSEOUT SUBMITTALS

A. Field quality-control reports.

B. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP 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.

C. 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.

D. 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 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 VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

## 1.9 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Furnish all equipment in cartons and within shrink-wrapped plastic to Project in ample time for installation. Properly tag and identify equipment furnished.

B. Storage and Protection: Store all equipment between delivery and installation in secure location that is dry, permanently enclosed, heated, and air conditioned as required to eliminate any condensation, moisture, heat or cold related damage.

## 1.10 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: Not less than 14 deg F and not exceeding 104 deg F.
2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F
3. Humidity: Less than 95 percent (noncondensing).
4. Altitude: Not exceeding 3300 feet.

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than seven days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary electrical service.

3. Do not proceed with interruption of electrical systems without Construction Manager's and Owner's written permission.
4. Comply with NFPA 70E.

## 1.11 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, horsepower, overall power, and other electrical requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Distance of VFC from load and conditions of signal cable installation.
4. Ambient and environmental conditions of installation location.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

## 1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURED UNITS

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. ABB.
2. AC Technology International Ltd (AC Tech); part of the Lenze Group.
3. Square D; a brand of Schneider Electric.
4. Yaskawa America, Inc; Drives Division.

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Variable torque.

D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged 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 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.

E. 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.

F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

G. 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 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 42 kA.
7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F.
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F
9. Humidity Rating: Less than 95 percent (noncondensing).
10. Altitude Rating: Not exceeding 3300 feet.
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 5 percent.
15. Output Carrier Frequency: Selectable; 0.5 to 12 minimum kHz.
16. Minimum 0.14µs Dt rise time or other improved technology which limits transient voltage spikes; such as soft switching.
17. Stop Modes: Programmable; includes fast, free-wheel, high slip and dc injection braking.

H. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 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.

K. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

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; NRTL approved.

6. Critical frequency rejection, with three 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.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. 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.

O. 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.

P. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. Alarm contacts as required that operates only when circuit breaker has tripped.

## 2.2 CONTROLS AND INDICATION

A. All VSDs:

1. Adjustments accessible from a keypad integral to VSD.

2. Auto/Manual, Start/Stop, and speed selection accessible on the front of the controller.

3. Power-on, run and trip monitor indications displayed by backlit LCD on the front of the controller.

4. Linear timed acceleration and deceleration, individually adjustable with 0.1 - 600 seconds range.

5. Minimum 40:1 controlled speed range.

6. Minimum 0.1-120 Hz output frequency range.

7. Adjustable Volts/Hz ratio with both factory preset and custom tunable options. Voltage boost adjustable in addition to V/Hz ratio.

8. Controller capable of restarting with the motor coasting in either forward or reverse direction without tripping.

9. Minimum Hertz (0-50 percent), maximum Hertz (50-100 percent).

10. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status, alarms, and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

    a. Network Communications Ports: Ethernet and RS-422/485.
    b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet and/or Echelon LonWorks; protocols accessible via the communications ports.

B. All “General Purpose” drives, optional for “Micro” drives:

1. Status Lights: Door-mounted LED indicators displaying the following conditions:

   a. Power on.
   b. Run.
   c. Overvoltage.
   d. Line fault.
   e. Overcurrent.
   f. External fault.

2. 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.

   a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

   b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

      1) Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

3. Historical Logging Information and Displays:

   a. Real-time clock with current time and date.
   b. Running log of total power versus time.
   c. Total run time.
   d. Fault log, maintaining last four faults with time and date stamp for each.

4. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

   a. Output frequency (Hz).
   b. Motor speed (rpm).
   c. Motor status (running, stop, fault).
   d. Motor current (amperes).
   e. Motor torque (percent).
   f. Fault or alarming status (code).
   g. PID feedback signal (percent).
   h. DC-link voltage (V dc).
   i. Set point frequency (Hz).
   j. Motor output voltage (V ac).

5. Control Signal Interfaces:

   a. Electric Input Signal Interface:

      1) A minimum of 2 programmable analog inputs: 0- to 10-V dc and 4- to 20-mA dc.
      2) A minimum of six multifunction programmable digital inputs.

   b. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:

      1) 0- to 10-V dc.
      2) 4- to 20-mA dc.
      3) Potentiometer using up/down digital inputs.
      4) Fixed frequencies using digital inputs.

   c. Output Signal Interface: A minimum of 2 programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:

      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (V dc).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set point frequency (Hz).

   d. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

      1) Motor running.
      2) Set point speed reached.
      3) Fault and warning indication (overtemperature or overcurrent).
      4) PID high- or low-speed limits reached.

6. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

   a. Network Communications Ports: Ethernet and RS-422/485.
   b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet and/or Echelon LonWorks; protocols accessible via the communications ports.

2.3 PROTECTION

A. All VSDs:

1. Lockable enclosure containing drive, line reactor, and fused exterior disconnect protecting all components. Enclosure large enough to facilitate ease of service, configured to fit in available mounting location and allow for rapid change-out of micro drive.

2. Includes capability of riding though power dips up to 2 seconds without a controller trip depending on load and operating condition. During ride through, drive uses energy generated by the rotating load as a power source for all electronic circuits.

3. Instantaneous electronic trip when the current demands of the invertor exceed its intermittent rating, 300 percent maximum.

4. Electronic overload circuit to protect AC motors operated by the VSD output from extended overload operation on an inverse time basis UL and NEC recognized as motor protection.

5. Enclosure, fuses, circuit breakers, and contactors as required allowing use as motor protection per strictest of regulatory requirements having jurisdiction.

6. Minimum 75 percent input line under voltage trip; average 120 percent over voltage.

7. Line-to-line and line-to-ground short circuit protection.

B. All “General Purpose” drives, optional for “Micro” drives:

1. Lockable exterior disconnect.

2. Internal disconnect to isolate the drive for service when in bypass operation.

3. Includes capability of riding though power dips up to 10 seconds without a controller trip depending on load and operating condition. During ride through, drive uses energy generated by the rotating load as a power source for all electronic circuits.

4. Minimum 42,000 RMS AISC fault withstand capability.

5. Electronic trip when the current demands of the inverter exceed its intermittent rating for 3 seconds, 150 percent maximum.

6. Electronic overload circuit to protect AC motors operated by the VSD output from extended overload operation on an inverse time basis UL and NEC recognized as motor protection.

7. Fuses, circuit breakers, and contactors as required allowing use as motor protection per strictest of regulatory requirements having jurisdiction.

8. Minimum 80 percent input line under voltage trip; average 110 percent over voltage.

9. Line-to-line and line-to-ground short circuit protection.

10. Input 3-phase AC line reactor (DC link not acceptable).

## 2.4 BYPASS SYSTEMS

A. "Micro" Drive: No bypass required. Provide "Spare" drives as follows:

1. For each building in project where "Micro" drives are utilized, provide one spare drive of each unique configuration (voltage/phase/HP) "Micro" Drive installed as part of project, minimum two if only one configuration is used. Deliver spare drives to Owner and provide Architect with letter signed by owner confirming receipt of spare "Micro" drives.

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

D. Bypass Controller: Three contactor bypass or two-contactor-style bypass that allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, IEC-rated contactor.

2. Output Isolating Contactor: Non-load-break, IEC-rated contactor.

3. Input Isolating Contactor: Non-load-break, IEC-rated contactor.

4. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration:

1. NORMAL/BYPASS selector switch.

2. HAND/OFF/AUTO selector switch.

3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.

4. Overload Relays: NEMA ICS 2.

a. Solid-State Overload Relays:

1) Switch or dial selectable for motor-running overload protection.
2) Sensors in each phase.
3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5) Analog communication module.

b. NO isolated overload alarm contact.

c. External overload reset push button.

## 2.5 OPTIONAL FEATURES

A. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

B. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

C. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Forces VFC to transfer to Bypass Mode and operate motor at full speed.
4. Causes display of Override Mode on the VFC display.
5. Reset VFC to normal operation on removal of override signal automatically.

D. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

E. Remote digital operator kit.

F. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

## 2.6 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VSD enclosure cover unless otherwise indicated. Pilot Lights: LED types; colors as required; push to test.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. 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.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Cooling Fan and Exhaust System: As required for NEMA 250, Type 12; UL 508 component recognized: Supply fan, with composite or stainless steel intake and exhaust grills and filters; 120 -V ac; obtained from integral CPT.

G. Output Cable: Provide sufficient special purpose VFC output cable for all power wiring between all VFCs and their respective loads, sized per the stricter of NEC, drive and motor manufacturer's recommendations, or as shown on drawings.

1. Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2. VFC Cable: Type TC-ER low-capacitance shielded VFC cabling with oversized crosslinked polyethylene insulation over tin-coated high strand count conductors, spiral-wrapped foil plus full coverage braided shields in direct contact with symmetrical ground conductors (one per power conductor), and sunlight- and oil-resistant outer PVC jacket.

3. Capacitance value core to core less than 75pF/m, core to shield less than 150pF/m.

4. Basis of design: Amercable TC-ER VFD cable, or equal by Beldon or Carol.

## 2.7 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.
B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
D. Proceed with installation only after unsatisfactory conditions have been corrected.
E. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 INSTALLATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required access, workspace clearances, and required clearances for equipment access doors and panels. Install VFCs in an upright position.

B. Install VFCs including all transformers, line reactors, bypass enclosures and other accessories, on walls or equipment racks level, upright, 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 or floor. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

### 3.3 CONTROL AND POWER WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support line, load, and control wiring in separate enclosures.

C. Install output cabling in strict accordance with manufacturers' recommendations. Provide for strain relief and cabling protection from damage. Verify cable length prior to installation and provide output line reactor if length exceeds that specified.

D. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.

2. Connect selector switches with control 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.

## 3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 23 Section "Identification for HVAC Systems."

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.

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

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 Construction Manager 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 before Final Completion and Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.

   b. 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.

   c. Re-tighten all connections as required.

   d. Generate report for inclusion in close-out documentation including color thermography printouts showing acceptable results.

   e. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFCs will be considered defective if they do not pass tests and inspections.

G. 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.

## 3.6 STARTUP SERVICE

A. Provide services of a manufacturer's factory –authorized service representative to inspect complete installation, start and adjust each drive, and train the Owner in drive operation, maintenance, and adjustment.

B. Coordinate services of adjustable speed drive factory –authorized service representative, TAB Agency, and Controls Technicians to insure proper coordinated operation and system control.

C. Complete additional installation and startup checks according to manufacturer's written instructions.

D. Submit letter from manufacturer's factory –authorized service representative attesting to the satisfactory completion of installation and startup, with attached start-up / calibration forms for each drive with all appropriate adjustment settings itemized.

## 3.7 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. Fully adjust each adjustable speed drive including maximum and minimum speeds, rates of speed change, calibration, testing, and as otherwise required to meet the operational intent and all control sequences.

D. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six 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 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 and Construction Manager before increasing settings.

E. Set the taps on reduced-voltage autotransformer controllers.

F. Set field-adjustable circuit-breaker trip ranges as specified in Division 26.

## 3.8 PROTECTION

A. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

## 3.9 DEMONSTRATION

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

1. Submit letter from factory-authorized service representative attesting to the satisfactory completion of Owner’s training, signed by Owner’s representatives.

END OF SECTION 23 29 00

# SECTION 23 31 00 - DUCTWORK

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sheet metal duct materials and construction.
2. Sheet metal duct fittings materials and construction.
3. Flexible duct and connectors.
4. Ductwork ancillary components materials and construction.

### 1.3 DEFINITIONS

A. Aspect Ratio: The ratio of duct width to height.

B. Hydraulic Radius: The ratio of duct cross section area to perimeter, or practically, a term used to define flow resistance of duct with differing aspect ratios, with resistance to flow being approximately proportional to hydraulic radius.

C. NRC: Noise Reduction Criteria

D. Offset: A change in the duct centerline location but not direction occurring within one piece of duct.

E. RGD: Registers, Grilles, and/or Diffusers

F. STC: Sound Transmission Class

### 1.4 PERFORMANCE REQUIREMENTS

A. Provide duct system able to withstand the loads and stresses described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and these contract documents.

B. Fabricate outdoor duct and casings to withstand wind load and snow load indicated on Structural series drawings and specifications. Calculate the snow load as a negative pressure on the top duct surface.

C. Provide all duct systems continuously electrically bonded to ground.

1.5 SUBMITTALS

A. Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.

B. Identify in writing, any proposed deviations from contract Drawings and Specifications.

1. Highlight all changes from plans required by obstructions and job conditions.

2. Bring any proposed deviations from contract plans and specifications to Architect's attention in writing, by separate letter attached to submittal with proposed deviations, along with samples for clarification, demonstrating benefit to Owner.

C. Product Data: Submit for approval annotated Shop Construction Standards showing upgrades as required for conformance in detail to specifications for all factory and shop fabricated air ducts, components, and accessories.

D. Shop Drawings:

1. Prepare and submit 1/4" = 1’ scale or larger shop drawings for all areas within 30 days after contract award unless Architect, Construction Manager, and Owner agree in writing upon another shop drawing schedule. Refer to section 01 33 00 – Submittals for additional information. Include approved Ductwork Accessories after approval as part of Section 23 33 00 submittals.

a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
b. Factory- and shop-fabricated ducts and fittings.
c. Duct layout indicating sizes, configuration, liner material, and SMACNA pressure class required for all duct.
d. Indicate duct elevation above floor (top and bottom of ducts), bottom of structure especially at critical passages, and ceiling height for each room.
e. Dimensions of main duct runs from building grid lines.
f. Fittings.
g. Reinforcement and spacing.
h. Seam and joint construction.
i. Penetrations through fire-rated and other partitions.
j. Equipment and accessories installation based on equipment being used on Project.
k. Indicate locations and sizes of all dampers, turning vanes, access doors and panels, and other required accessories.
l. Hangers and supports, including methods for duct and building attachment and vibration isolation.

E. Coordination Drawings:

1. Prepare 1/4" = 1’ scale or larger drawings for all Library areas within 15 days after Duct Shop Drawing approval unless Architect, Construction Manager, and Owner agree in writing upon another coordination drawing schedule. Refer to Section 01 31 00 – Project Management and Coordination, Section 01 33 00 – Submittals and Section 23 33 00 – Ductwork Accessories, for additional information.

a. Begin with approved shop drawings.

b. Incorporate dimensions shown on contract documents and those of actual equipment proposed. (Including duct, piping, equipment, suspended ceiling components, light fixtures, structural steel adjacent to duct, service clearance, etc.)

c. Detail duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

d. Show adequate sections, elevations and plan views required to demonstrate reasonable installation and service is possible.

e. Include 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.

f. Include all structural members to which duct will be attached.

g. Coordinate with and include TAB agency commentary as described in Section 23 05 93.

h. Include size and location of all floor, wall, and roof openings. Highlight penetrations of smoke barriers and fire-rated construction

i. Include items penetrating finished ceiling including the following:

1) Lighting fixtures.
2) Air outlets and inlets.
3) Mechanical Equipment.
4) Fire Alarm Devices.
5) Speakers.
6) Sprinklers.
7) Soffits.
8) Access panels.
9) Perimeter moldings.

2. Submit Coordination Drawings to Architect and each affected Prime Contractor for review and coordination in accordance with the schedule agreed upon during the coordination meetings.

3. Deliver originals and additional copies of revised signed and accepted Complete Coordination Drawings as follows:

a. Owner: originals
b. Architect: 1 copy
c. Construction Manager: 1 copy.
d. Each affected other Prime Contractor: 1 copy.

## 1.6 CLOSEOUT SUBMITTALS

A. Contract Closeout Submittals: Comply with requirements of SECTION 01 77 00 – Closeout Procedures, including submission of operating and maintenance instructions as item in "Operating and Maintenance Data" manual described in that section.

B. Field quality-control reports – duct leakage, duct cleanliness.

## 1.7 QUALITY ASSURANCE

A. Provide ductwork by experienced and approved workers specializing in sheet metal fabrication and installation in accordance with the stricter of the below referenced standards and the requirements outlined in these contract documents.

B. Referenced Standards

1. The latest editions of the publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

2. American Society of Civil Engineers (ASCE):

   a. ASCE7 Minimum Design Loads for Buildings and Other Structures

3. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

   a. ASHRAE / ANSI 62.1 – Ventilation for Acceptable Indoor Air Quality.
   b. ASHRAE / ANSI 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings

4. American Welding Society (AWS)

   a. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports.
   b. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports.

5. American Society for Testing and Materials (ASTM):

   a. A167 99 Standard Specification for Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip
   b. A653-09 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
   c. A1011-09a Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
   d. B209 07 Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate
   e. C1071-05e1 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
   f. D6386 Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

g. D7803 Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating
h. E84-09a Standard Test Method for Surface Burning Characteristics of Building Materials

6. National Air Duct Cleaners Association (NADCA):

a. ACR "Assessment, Cleaning and Restoration of HVAC Systems", for duct cleanliness standards.

7. National Fire Protection Association (NFPA):

a. 90A Standard for the Installation of Air Conditioning and Ventilating Systems

8. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

a. HVAC Duct Construction Standards, Metal and Flexible
b. HVAC Air Duct Leakage Test Manual

## PART 2 - PRODUCTS

### 2.1 DUCT MATERIALS

A. General Material Requirements:

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated.

2. Provide sheet metals per mill specs and free of pits, voids, seam or roller marks, stains, discolorations, inadvertent bends and kinks, and other imperfections.

B. Standard Supply, Return and Exhaust: Galvanized steel, ASTM A-653/653M G90, lock forming quality, unless otherwise specified.

C. Standard Supply, Return and Exhaust duct which will be exposed to view in the finished project and will not be externally insulated or painted: Galvannealed steel, ASTM A-653/653M G90, lock forming quality, unless otherwise noted.

D. Standard Supply, Return and Exhaust duct which will be exposed to view in the finished project and will be painted: Galvannealed steel, ASTM A-653/653M G90, lock forming quality, prepared for painting via mill phosphatizing and subsequent heat treatment in accordance with ASTM D6386 and ASTM D7803 as applicable, unless otherwise noted.

1. Consider all ductwork serving the library areas as being painted.

E. Flexible Ducts:

1. Flexible Duct (standard ventilation air register, grille, and diffuser connections where noted on Drawings. Maximum installed length to be 5'-0"): Medium pressure CPE or polymeric coated woven fiberglass cloth liner, enclosed spring steel wire, R-6 fiberglass insulation covered by metalized polyester film bi-directionally reinforced vapor barrier. Similar to types S-TL (uninsulated for field insulation), M-KE, or M-KC, with FlexFlow elbow supports, all by Thermaflex (design make).

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, 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, and use stainless steel fasteners.

## 2.2 RECTANGULAR DUCTS AND FITTINGS

A. Conform to appropriate SMACNA rectangular duct reinforcement tables and figures for the velocity-pressure classification duct construction required as defined in part three of this document, and additionally as follows.

1. Seal all joints and seams in accordance with SMACNA seal classification required for duct in question.

a. Additionally, seal field assembled longitudinal seams for seal class B duct.

2. Transverse Joints: in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure for "Rectangular Duct/Transverse Joints".

a. For all duct requiring reinforcement, provide SMACNA T-24 or T-25 type flanged duct connection system at traverse joints.

1) Joints may be factory manufactured slip on type or integrally shop fabricated onto the duct sheet metal on machinery designed for that purpose. Corner closure pieces are required at each corner.

2) Manufacturers: Subject to compliance with requirements, available manufacturers offering pre-manufactured slip on reinforcement products that may be incorporated into the Work include, but are not limited to, the following:

a) Ductmate Industries, Inc, or equal.
b) Lockformer TDC or equal.
c) Nexus PDQ type G or J or equal.

3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular 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."

4. Tie rods are not permitted on duct or plenums narrower than 72". Where an option for tie rod or heavier gauge sheet metal / shorter joint length / higher category reinforcement is presented in table, the heavier, shorter, more reinforced duct with no tie rods is required.

B. Offsets:

1. Where offset dimension is equal to or less than 0.2 times duct dimension in plane of offset, offset may be angled at maximum 15 degrees (SMACNA type 1).

2. Where offset dimension is greater than 0.2 times duct dimension in plane of offset (example: 10 x 20 duct offset in plane of 10" dimension greater than 2 inches), offset to consist of paired curved elbows, each of the required angle, combined into one fitting (SMACNA type 3).

   a. Conform to elbow requirements as indicated below.
   b. Offset may be replaced with paired curved elbows if required for installation, otherwise provide combined fitting.

C. Transitions of shape or cross section:

1. Reductions in cross section shall have a maximum included cone angle of 60 deg., with a maximum single side angle of 45 deg. from axial, unless otherwise specified in writing.

2. Transformations of section without a net reduction of cross section shall have no section of reduced hydraulic radius nor any local expansion of more than 15 deg. net included cone angle, as defined by ASHRAE and SMACNA.

3. Expansion sections, unless specifically drawn and noted otherwise, shall have:

   a. No section of reduced hydraulic radius
   b. No section of local expansion of more than 15 deg. net included cone angle.
   c. No single side expansion angle of more than 15 deg. from axial unless otherwise specified in writing.

D. Elbows:

1. Make all changes in direction (as opposed to offsets above where direction remains the same) regardless of angle with elbow fittings unless specifically drawn and noted otherwise.

2. Curved Rectangular Elbows:

   a. Along critical pressure drop paths, provide curved rectangular elbows.

      1) Critical pressure drop paths shall be as indicated on drawings or if not indicated shall be considered to be entire duct run from air handling unit along mains to or from furthest terminal. Systems with more than one main branch shall be considered to have more than one critical pressure drop path.

      2) Provide critical path elbows with throat radius not less than dimension of duct in plane of radius or use smaller inner radius elbows with splitter vanes such that the ratio of inner to outer radius of curvature of any section of the elbow shall not be less than 1/2.

   b. Along non-critical pressure drop paths, curved rectangular elbow radius requirements may be relaxed to a throat radius not less than one half the dimension of the duct in plane of radius or use smaller inner radius with splitter vanes such that the ratio of inner to outer radius of curvature of any section of the elbow shall not be less than 1/3.

   c. Construct all curved elbows of increasing or decreasing cross section in accordance with critical pressure drop path criteria.

   d. Fabricate splitter vanes per SMACNA Duct Manual construction standards.

3. Mitered rectangular elbows

   a. Only elbows not along critical pressure drop path may be of curved or mitered construction.
   b. Mitered rectangular elbows with angle of bend under 15 deg. may have miter at duct end similar to SMACNA type 1 offset.
   c. Provide turning vanes in mitered rectangular elbows with angle of bend over 15 degrees.
   d. Mitered elbows with angle of bend over 100 deg. or less than 80 deg. shall not use commercially available 90 deg. turning vanes

4. Double Wall Turning Vanes

   a. Provide for mitered rectangular elbows of equal inlet and outlet or increasing cross section

   b. Blades of hollow double wall construction, with smaller radius sheet metal form nested outside larger radius form, tapering down gradually to and welded at double thickness edge, designed for specific spacing and alignment to minimize separation of flow and pressure drop through air duct elbows.

   c. Properly spaced to result in constant cross-section area between blades: smaller radius blades to have closer spacing

   d. Maximum spacing 3 inch, unless otherwise approved.

   e. Acoustical type where called for or where installed in acoustically lined ductwork.

f. Provide products by one of the following:

1) Titus or equal
2) Elgen or equal
3) Hardcast or equal.

E. Duct Branches:

1. Install branches, inlets, and outlets so that air turbulence is reduced to a minimum and air volume properly apportioned. Install airflow adjustment devices at all junctions to permit adjustment of the amount of air entering or leaving the branch.

2. Where a duct branch is to handle more than 25 percent of the air handled by the duct main, use a complete elbow as specified, assembled into a single fitting with the main duct. Size the separate branch and remaining main as shown on the drawings, and partition the division of the combined duct such that each of the branch and main have the same velocity, with cross sectional area proportional to the respective airflow. Join the leading / trailing edge where the branch and main meet airtight via welding or brazing.

3. Where a duct branch is to handle less than 25 percent of the air handled by the duct main, construct the branch connection with a 45 degree side take-off with volume damper in branch line close to takeoff. Round branches off of rectangular main, use 45 deg. entry takeoff with integral transition to round.

a. Supply: increase duct dimension on upstream side of branch by 25 percent, minimum 4 inch.
b. Return: increase duct dimension on downstream side of branch by 25 percent, minimum 4 inch.
c. Multiple flow direction takeoffs: provide twin entries or bell mouths.

4. Where an air-diffusion device is shown as being installed in close proximity to (less than one main duct width) the side, top, or bottom of a duct, provide a commercially manufactured vaned volume extractor fitting to allow adjustment of the air quantity and to provide an even flow of air across the device it services.

F. Duct Entries

1. Wherever air does not enter the duct system from grilles, registers, or louvers, but instead enters directly from an enclosed or exposed plenum space, provide a duct entry transition with a minimum area ratio of inlet to nominal duct size of 2:1 unless otherwise specifically shown and noted.

2. Duct entry may be angled (pyramidal or conical) or with bell-mouth radius.

a. Provide angled duct entries with a maximum single side angle to axial of 30 deg. Any combination of sides, top, and bottom may be angled (or conical for round duct) to suit space restrictions, but maintain the specified area ratio.

b. Provide bell-mouthed entries with radius as required maintaining the specified area ratio.

3. Provide entry grille or if not shown, provide at minimum 1/2 inch welded wire mesh (WWM) secured over the large side of the opening of all duct entries.

## 2.3 ROUND 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 indicated static-pressure class unless otherwise indicated.

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. Spiral lock-seam duct, joints, and fittings:

1) Lindab Inc.
2) McGill AirFlow LLC.
3) SEMCO Incorporated.
4) Sheet Metal Connectors, Inc.
5) Spiral Manufacturing Co., Inc.

b. Longitudinal fusion-welded duct, joints, and fittings as described in appropriate SMACNA manuals and herein – shop fabricated.

c. 26 ga. G-60 longitudinal snap-lock construction duct, joints, and fittings.

B. 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", and as follows:

1. Spiral lock seam duct:

a. Machine locked spiral seams with or without formed standing reinforcement ribs.
b. Leakage through the duct wall and joints certified no greater than design make.
c. Provide minimum 12 ft. long un-joined lengths, except where interrupted by fittings.

2. Longitudinal seam duct shall have fusion-welded butt seams.

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.

3. Snap-lock seam duct:

a. Limit snap-lock construction components and systems to concealed round duct run-outs to individual diffusers, registers, and grilles, in sizes 12 inch and under, with all transverse and longitudinal seams sealed.

b. Longitudinal seams field assembled by interlocking machine formed sprung tabs, with sealant brushed on before and after assembly.

c. Provide minimum 10 ft. long un-joined lengths, except where interrupted by fittings or shorter lengths are required to work through existing structure.

C. 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", and as follows:

1. 24 in. diameter and less: slip fit collars or sleeve couplings, reinforced by rolled beads, insertion length 2 inch. Secure with hexagon head drill point screws or other approved mechanical fasteners 6 inch o.c. max and duct sealant.

2. Over 24 inch to 42 inch diameter, general, concealed joints: Provide roll formed, welded angle ring flanges similar to SMACNA T-24 or T-25 configuration. Attach flange to duct with internal stitch or button welds 6 inch o.c. max and duct sealant. Size angle ring gauges per SMACNA recommendations. Secure with #10 “Tec” screws 6 inch o.c. maximum, seal with closed cell gasket.

3. Exposed over 24 inch diameter, all over 42 inch diameter: two piece angle ring flanges, loose fit outer ring in a "Van Stone" configuration. Provide a 5/8 inch flange inner ring as a gasketing surface for sealing, integrally rolled or attached to the pipe with internal button or stitch welds 6 inch o.c. max and duct sealant. Provide outer rolled, welded angle ring sized per SMACNA recommendations. Secure with bolts 8 inch o.c. maximum, seal with closed cell gasket.

D. Elbows:

1. Fabricated to a centerline radius of minimum 1.5 times the cross-section diameter.

   a. Where space constrictions do not allow specified centerline radius or where shown as such on drawings only, provide mitered elbow of fully welded construction with single thickness turning vanes spaced 3 inch o.c. max.

2. For use with snap-lock round duct, where allowed as described above: Gored adjustable elbows, seal adjustable joints after installation.

3. For standard bends (ex. 45 deg. and 90 deg.), diameters through 9 inch: Two-section stamped and welded 22 ga. elbows.

4. Diameters 10 inch through 30 inch, any angle: Gored standing seam construction similar to United McGill “UNI-SEAM”. Less than 36 deg. - two gores, 36 deg. to 72 deg. - three gores, over 72 deg. - five gores.

5. Diameters over 30 inch and odd angles under 10 inch: Gored construction with gores stitch welded 6 inch o.c. max and sealed with duct sealant. Less than 35 deg. - two gores, 36 deg. to 71 deg. -three gores, over 71 deg. - five gores.

E. Tees and Lateral Branches: 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", and as follows:

1. Bull-Headed Tees:

   a. Provide wye fitting with subsequent partial bend elbows for critical run bull-headed tees.
   b. Provide capped main and twin lateral branches as described below for general purpose bull-headed tees.
   c. Provide “bird-mouthed” fitting with turning vanes only where space restrictions require and where specifically shown as such on the drawings.

2. Fabricate lateral tees and all branches with fittings as described herein:

   a. Fabricate to longitudinal welded duct standards. Where possible, provide gored standing seam construction similar to United McGill “UNI-SEAM”, otherwise stitch or button welded or riveted. Seal all joints.

   b. Fitting entrance free of weld build-up or spatter, burrs, or irregularities, not projecting into either the main or branch runs.

   c. Provide manual volume damper at all branch connections.

   d. Typical round branch connections to round main duct, provide 45 deg. reducing lateral takeoff fitting, with subsequent elbow resulting in required branch angle to main.

      1) Where space restrictions do not permit this combination, provide 90 deg. angled rectangular to round takeoff fitting “birdmouthed” to main, or conical takeoff with similar loss coefficient.

      2) For critical run (ie. maximum pressure drop) round branch connections to round main ductwork, provide high performance 45 deg. reducing conical lateral takeoff fitting, with subsequent elbow resulting in required branch angle to main.

      3) Exposed, duct side mounted register connections may be tapped into side wall of length of duct. Where an air-diffusion device is shown as being installed in close proximity to (less than one main duct width) the side, top, or bottom of a duct, provide a commercially manufactured vaned volume extractor fitting to allow adjustment of the air quantity and to provide an even flow of air across the device it services.

F. Turning Vanes:

1. As described for mitered rectangular elbows of unequal inlet and outlet cross section above.

G. Offsets:

1. All offsets to consist of paired curved elbows, each of the required angle, combined into one fitting.

H. Transitions of shape or cross section and duct entries:

1. As described for rectangular duct above.

## 2.4 EXTERIOR DUCT

A. Construction as detailed above with the additional requirements listed herein.

B. Seal all exterior duct completely water tight, including all longitudinal and transverse seams, fittings, and branch connections. Seal both during assembly and from the exterior. Use only exterior all weather grade gaskets and sealants. Apply sealants neatly, avoiding exposed sealant on surface. Where sealant must be exposed for function apply in neat fillets.

C. Fabricate all transverse joints using an **INTEGRAL** standing flange reinforcement similar to SMACNA T-24 or T25 as described in the SMACNA HVAC Duct Construction Standards Manual. Use of "slip-on" reinforcing flanges not permitted.

D. Install all exterior duct with minimum 1 inch per 10 ft pitch to avoid standing water puddles on top surface.

## 2.5 DUCTWORK ANCILLARY COMPONENTS

A. In general, duct accessories associated with specialized requirements which are called out and / or scheduled on the drawings are specified in section 23 33 00 – Air Duct Accessories. The ancillary components included in this section are generally required in all air duct systems, need not be specifically called for on the drawings other than by specification or standard symbols and abbreviations, and are required to be detailed in the shop standards submittal.

B. Acoustical and Thermal Duct Liner:

1. Refer to Specification Section 23 07 00 – HVAC Insulation for duct liner specifications.

2. Where duct liner is used, enlarge ductwork in both directions by double the nominal duct liner thickness to size required to provide for free area dimensions as shown on the drawings.

3. Duct liner used for sound attenuation purposes only to be minimum 1 inch thick or thicker as specified on the drawings.

4. Duct liner used in lieu of external thermal insulation is required to meet the insulation value and associated thickness requirements of Section 23 07 00.

5. Duct liner materials and installation, as specified in Section 23 07 00, may be submitted under either this section or in Section 23 07 00.

C. Duct Connectors:

1. Flange Connectors

a. Refer to flange reinforced transverse joint system described under duct construction above. Flanged connections to system components other than adjacent duct sections may be fabricated similar to a transverse joint. If required to connect to equipment or components of different configuration provide flanged connector custom fabricated of reinforcement shapes as specified.

b. Material: Match adjacent duct.

2. Flexible Connectors - Duct to Equipment:

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) Ductmate Industries, Inc.
2) Duro Dyne Inc.
3) Ventfabrics, Inc.
4) Ward Industries, Inc.; a division of Hart & Cooley, Inc.

b. Provide factory fabricated flexible connectors with heavy gauge metal edge bands double roll crimped each side onto water, flame-retardant, mildew resistant, NFPA approved flexible fabric connector strip.

c. Metal Edge Bands: 2 strips of 2-3/4 inches wide, 0.028-inch- thick G90 galvanized sheet or stainless steel, or 0.032-inch- thick aluminum sheets. Provide same metal and corrosion resistance as connected ducts.

d. Fabric Connector Strip: minimum 3-1/2 inches wide, 20 oz. per square yard fiberglass fabric strip double coated with neoprene (general service), hypalon (outdoors), nitrile (chemical resistant service similar to fume hoods), or silicone (high temperature service similar to kiln or engine exhaust).

e. Coatings and Adhesives: Comply with UL 181, Class 1.

3. Electrical Bonding Connectors:

a. Provide complete system of electrical bonding across all electrical discontinuities resulting from non-conducting duct work components. Refer to section 26 05 26 - Grounding and Bonding of Electrical Systems.

D. Airflow Adjusters:

1. Single Blade Volume and Splitter Dampers:

a. Construction per SMACNA Duct Manual and as noted below.

b. Materials: Match associated duct corrosion resistance requirements.

c. Provide double wall airfoil blade dampers where duct velocity is over 1000 fpm nominal.

d. Maximum blade width 12 inches.

e. Multiple dampers or manufactured multi-blade damper above 600 square inches duct cross section.

f. Bearings and Adjusters:

1) Heavy duty quadrant adjusters with 12 gauge offset handle, captive bolt/wing nut lock in 2” minimum radius slot, split clamp with bolt on 3/8” shaft up to 300 square inch duct, ½” shaft for duct up to 600 square inch cross section.

2) Closed end bearings for duct rated for 2" WG and above.

3) Standoff under quadrant placing quadrant outside of specified duct insulation. Insulate between duct and quadrant.

4) When occurring in acoustically lined ducts, install with insulated "build-outs" per Duct Manual.

2. Multi-blade Manual Volume Dampers:

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) Air Balance Inc.; a division of Mestek, Inc.
2) American Warming and Ventilating; a division of Mestek, Inc.
3) Flexmaster U.S.A., Inc.
4) McGill AirFlow LLC.
5) Nailor Industries Inc.
6) Ruskin Company.
7) Trox USA Inc.
8) Vent Products Company, Inc.

b. Materials: Match associated duct corrosion resistance requirements.

c. Standard leakage rating.

d. Suitable for horizontal or vertical applications.

e. Frames:

1) Hat-shaped channels 0.064-inch minimum thickness.
2) Mitered and welded corners.
3) Flanges for attaching to walls and flangeless frames for installing in ducts.

f. Blades:

1) Opposed-blade design standard unless otherwise noted.

2) Stiffen damper blades for stability.
3) Formed single thickness blades allowed up to 1000 feet per minute (fpm) design duct velocity; provide airfoil blades above 1000 fpm.
4) Galvanixed-steel, 0.064 inch thick.

g. Blade Axles: full length of damper blades, bearings at both ends of operating shaft.

h. Bearings: Oil-impregnated bronze, molded synthetic, or stainless-steel sleeve bearing as applicable.

i. Tie Bars and Brackets: Galvanized steel.

j. 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.

k. Jackshaft:

1) Provide as required for adjusting multi section multi-blade dampers simultaneously.

2) Size: 1-inch diameter.

3) Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

4) Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

3. Vaned Volume Extractors

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) Variturn RXVA by Carnes, Inc.
2) Model AG-45 / AG-225 by Titus Inc.

b. Factory assembled gang-operated parallelogram mounted single wall turning vanes, designed to be mounted between main and branch ducts at branch duct connections and vary the flow rate extracted to branch air while minimizing turbulence and associated pressure drop.

c. Galvanized steel construction installed with sheet metal screws provides stable operation up to 2500 feet per minute main or branch duct velocity.

d. Single wall radius formed turning vanes with flat trailing and leading edges provide uniform air distribution across the branch duct and overlap in closed position for tight close-off. Vanes spaced no greater than one inch on center up to 18 inch length (measured in direction of main duct airflow) or no greater than two inches on center up to 36 inch length.

e. Fully adjustable from closed (zero protrusion into main duct, zero branch duct flow rate), to fully open (30 degree protrusion into main duct).

f. Where extractor vane length is less than dimension of main duct, provide branch duct with side extensions fully enclosing sides of extractor up to the full open position.

1) Where installed in horizontal duct and the bottom of the main and branch ducts are not in the same plane, provide extension support foot at end of bottom side extension.

g. Provide with adjusting mechanism that securely locks in adjusted position and unlocks allowing for smooth infinite adjustment from closed to open.

1) For extractors up to 18 inches long serving branch ducts provide with internal crank linkage operated by heavy duty manual quadrant and 3/8 inch square shaft.

2) For extractors over 18 inches long serving branch ducts, provide with double wire rod push-pull mechanism secured with welded stud, formed steel captive washer and wing nut.

3) For extractors serving immediately adjacent registers, provide with screw gear operated internal crank linkage operated by key through register face.

## 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. 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.

C. Flanged Joint Sealant: Comply with ASTM C 920.

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).

7. 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."

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. 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. Provide complete system of Air Duct Hangers and Supports as required by the Air Duct systems included. Refer to Section 23 05 29 – "Hangers and Supports for HVAC Components" for details of Hanger and Support requirements for Air Ducts and associated components.

B. Provide complete system of Air Duct Vibration and Movement Control as required by the Air Duct systems included. Refer to Section 23 05 43 – "Mechanical Vibration and Movement Control" for details of vibration isolation and movement control requirements for Air Ducts and associated components.

C. Flexible Duct Supports and Accessories:

1. Elbow Supports: UL listed for plenum installation molded fiber reinforced plastic elbow support at connections to ceiling mounted devices designed to maintain tension in flex duct and eliminate collapsed elbows. Basis of design: Thermaflex FlexFlow elbows.

2. Flexible Duct Supports: UL listed for plenum installation molded fiber reinforced plastic 1-1/2" wide straps adjustable for 4" to 16" diameter flex duct, supports duct without damaging vapor barrier or collapsing soft insulation or duct. Basis of design: Thermaflex FlexTie straps.

3. Clamps: Re-usable stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size, or single use "zip-tie" strap of plenum rated plastic, sizes 3 through 10 inches diameter maximum.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine conditions under which duct work is to be installed for compliance with requirements for proper installation.

1. Check all drawings for detailed information and locations and field verify all conditions affecting installation.
2. Notify Architect in writing of any conditions detrimental to proper and timely installation.
3. Obtain Architect's approval before fabrication of any changes in size required by obstructions and job conditions.
4. Proceed with installation only after unsatisfactory conditions have been corrected in an acceptable manner.
5. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 DUCT FABRICATION

A. Fabricate and install as shown on Drawings and in manner coordinated with all construction requirements.

B. Sizes shown on plans are clear inside duct dimensions representing the design hydraulic radius of the duct. Generally, fabricate ductwork of sizes shown on plans. During field verification, confirm that duct of aspect ratio shown fits within general construction constraints coordinated with all other trades. Adjust aspect ratio, joint spacing, reinforcement, etc., as required during coordination process to fit duct of equivalent hydraulic radius where shown. If duct of reduced hydraulic radius is required due to field conditions, submit RFI for direction before proceeding.

C. Flexible Connections: Provided at intake and discharge connections to all motor powered fan air handling equipment and other vibration isolated air handling component connections.

D. Fabricate all ductwork to the SMACNA pressure classification reinforcement standards shown on the drawings and to the following minimum standards.

1. Conform to special duct pressure classification requirements for all duct between air handler blowers and last fire or fire/smoke damper in series, and duct after the last fire or fire/smoke damper in series up to the next 90 deg. turn:

a. Fabricate to the SMACNA pressure classification reinforcement standards required by the system supply or return blower dynamic stall pressure; assume the larger of 200% of external operating pressure scheduled or 150% of fan total pressure listed as a minimum. VIF with approved equipment fan curves and adjust pressure classification values accordingly.

2. Where there are no fire or fire / smoke dampers and past the 90 degree turn mentioned above, complete to the last branch duct volume damper, VAV box, induction unit, or other pressure restricting device, fabricate duct to pressure classification as required by the system supply or return operating pressure listed on the drawings, minimum plus or minus two (2) inch water column.

3. Fabricate branch run-out duct between the last pressure restricting device and the air terminal register, grille, or diffuser to minimum plus or minus one (1) inch water column pressure classification.

E. Deliver and store all duct with duct interior clean and all openings sealed with film designed for the purpose of keeping uninstalled duct clean. Unless section of duct is being actively extended during construction, keep all openings and RGD properly sealed and prevent entrance of dust, dirt, construction debris, etc.

F. Extend all access openings, damper rods, and levers to outside of external insulation for convenience of operation and maintenance.

G. Provide all necessary transitions, fittings, aspect ratio changes, etc., as required to install duct work. Where aspect ratio changes are required to fit within structural or other existing construction constraints, provide duct of equal or larger hydraulic radius.

## 3.3 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 concealed in general construction unless otherwise specified or indicated on Drawings.

C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Provide all necessary openings, sleeves, hanger inserts, chases, recesses, etc., in general construction work. Coordinate duct openings provided by others in ample time to avoid delays.

E. Provide collars to trim all duct openings in general construction work.

F. Make final ductwork connections to equipment where indicated on the drawings.

G. Install ductwork in all spaces as high as possible and in locations to avoid interference with recessed lights, piping, general construction, etc.

H. Install round ducts in maximum practical lengths.

I. Install ducts with fewest possible joints.

J. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

K. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

L. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

M. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

N. Route ducts to avoid passing through transformer vaults, electrical equipment rooms and enclosures, and stairwells.

O. 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.

P. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

## 3.4 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 and surrounding heat affected zone 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.

## 3.5 DUCT SEALING

A. Make system air tight / water tight as required and approved, replacing any poor joints or careless work. Fabricate ductwork to the following SMACNA leakage standards:

1. Seal Class B – 2 inch w.g. and less general supply, return, and exhaust ductwork.

## 3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with the requirements of the following:

1. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
2. Section 23 05 29 – Hangers And Supports for HVAC Components.
3. Section 23 05 43 – Mechanical Vibration and Motion Control.

B. Comply with the additional requirements below:

1. SMACNA load tables do not provide for external loads on duct: provide for 200 lb external load on all duct hangers and supports. Increase hanger and support sizes from SMACNA tables accordingly:

   a. Minimum band size 20ga. x 1 inch.

   b. Duct 48” wide and larger; provide trapeze style support of metal channel framing or angle iron, suspended from threaded rods.

   c. Hanger bands to extend down sides and turn under bottom 1 inch minimum for all duct sizes. Minimum (2) #10 sheet metal screws per hanger (one each on side and bottom), (2) screws minimum on sides for duct over 12 inches tall, 12 inches on center max.

2. Hangers Exposed to View:

   a. Rectangular duct: threaded rod and angle or channel supports.
   b. Round duct: twin half round bands 14 ga min., and threaded rods.

3. Provide hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

4. 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.

5. Do not allow flexible duct to rest on general construction. Support flexible duct at maximum 3 feet on center.

## 3.7 CONNECTIONS

A. Make connections at all intake and discharge connections between duct and vibration producing equipment with fans, etc.., where duct passes through building expansion joints, and as shown on the drawings, with flexible connectors as specified.

1. Round connections: Adhesive and approved metal draw bands; ends tightly bolted together.

2. Rectangular flanges: Material securely held in grooved seam, tightly clipped or screwed on 6 inch centers.

3. Connections not over 2 inch between duct and equipment, with at least 1 inch excess material.

4. Install neatly so as not to interfere with air flow through connection. Provide round metal center ring or rectangular metal center collar to prevent flex fabric collapse inside of nominal connected duct dimensions.

5. Provide complete electrical continuity of duct systems to ground, bridging all flexible duct connectors and other non-conductive duct with grounding jumpers as described in Section 26 05 26 – Grounding and Bonding of Electrical Systems.

B. Registers, Diffusers, and Grilles:

1. Install flexible duct connections to registers, diffusers, and grilles with no more than 20 degree unsupported bend in flex. Where horizontal duct connects to vertical axis collar (ex., ceiling mounted diffuser), provide elbow support as specified or hard elbow.

   a. Where flexible duct is not electrically continuous between metallic duct and Register, Grille, or Diffuser as specified in section 26-05-26 - Grounding and Bonding of Electrical Systems, provide with grounding conductor or jumper as specified, maintaining continuity between RGD and ductwork.

2. Exposed, duct side mounted: Mount outlet outside of air stream with extension collars full size of register or grille frame outside margin, with turned in duct flange and turned out terminal mounting flange. Provide vaned air extractor with internal mechanism / external rotating knob adjuster.

3. Exposed ductwork hard piped connections: per Duct Manual.

## 3.8 PAINTING

A. Ductwork systems serving libraries will be painted. Provide ductwork material and finishes suitable for painting. Division 09 Painting Sections for additional information.

## 3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

C. Electrical Bonding Continuity Testing: Test each entire Ductwork and Ductwork Accessories system for ground bonding continuity in accordance with section 26 05 26 - Grounding and Bonding of Electrical Systems. Include test report demonstrating approvable bonding as part of commissioning and closeout documentation.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

## 3.10 DUCT CLEANING

A. Clean new 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.

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.

## 3.11 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 - "Testing, Adjusting, and Balancing for HVAC."

END OF SECTION 23 31 00

# SECTION 23 34 00 - HVAC FANS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.

### 1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
B. Operating Limits: Classify according to AMCA 99.

### 1.4 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also 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. Fan speed controllers.

B. Shop Drawings: 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.

## 1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustical tile.
3. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

## 1.7 CLOSEOUT SUBMITTALS

A. Field quality-control reports.
B. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

## 1.8 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

## 1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.
B. Coordinate sizes and locations of existing roof curbs, and roof penetrations with actual equipment provided.

# PART 2 - PRODUCTS

## 2.1 ROOF VENTILATORS

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. Acme Engineering & Manufacturing Corporation.
2. Breidert Air Products.
3. Carnes Company.
4. Greenheck Fan Corporation.
5. Hartzell Fan Incorporated.
6. Loren Cook Company.
7. New York Blower Company (The).
8. PennBarry.

B. 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.

C. Fan Wheel: Aluminum hub and blades.

D. Accessories:

1. Disconnect Switch: Nonfusible 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: Parallel-blade dampers with electric actuator; wired to close when fan stops. Refer to 23 09 00.

E. Roof Curbs: It is the intent to reuse existing roof curbs left by demolition.

## 2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Electrical Requirements for HVAC Equipment."

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.

B. Enclosure Type: Totally enclosed, fan cooled.

C. Variable Speed Operation:

1. Single Phase: Electronically commutated motor (ECM) shall be of permanent magnet, brushless DC premium efficiency design with variable speed electronic controller capable of maintaining constant speed, torque, and/or cfm as required by service, capable of accepting 0-10vdc or 4-20mA speed control signal from building management system. Adjustable slow start and gradual speed changes, permanently lubricated ball bearings, and extra quiet operation are all included.

## 2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to 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. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 INSTALLATION

A. Install power ventilators level and plumb.
B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
C. Install units with clearances for service and maintenance.

### 3.3 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 Division 23 Section "Ductwork."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 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. 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. Adjust damper linkages for proper damper operation.

5. Verify lubrication for bearings and other moving parts.

6. Verify that manual and automatic volume control dampers in connected ductwork systems are in fully open position.

7. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

8. Shut unit down and reconnect automatic temperature-control operators.

9. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

## 3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.
B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

END OF SECTION 23 34 00

# SECTION 23 36 00 - AIR TERMINAL UNITS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Bypass, single-duct air terminal units.

### 1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

### 1.4 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.

B. 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.

## 1.6 INFORMATIONAL SUBMITTALS

A. 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.

## 1.7 CLOSEOUT SUBMITTALS

A. Field quality-control reports.

B. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

## 1.8 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, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

# PART 2 - PRODUCTS

## 2.1 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 of the following:

1. Carnes.
2. Carrier Corporation.
3. Titus.

B. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Single wall.

1. Casing Lining: Adhesive attached, ½ inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071, 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 E 84.

a. Cover liner with nonporous foil.
b. Cover liner with nonporous foil and perforated metal.

2. Air Inlet: Round stub connection for duct attachment.

3. Air Outlet: S-slip and drive connections.

4. Access: Removable panels for access to diverting damper and other 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. 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 deg F. Include manual air vent and drain valve.

E. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:

1. Furnish with 24v control transformer.

## 2.2 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type and AHRI certification seal.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas where air terminal units 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.
C. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION

A. Install air terminal units according to NFPA 90A, "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.

## 3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
B. Building Attachments: In conformance with 23 05 23 Hangers and Supports for HVAC Components.

## 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 Division 23 Section "Hydronic Piping," connect heating coils with shutoff valve, control valve, and union or flange, balancing valve and union or flange.

C. Connect ducts to air terminal units according to Division 23 Section "Ductwork." Coordinate duct installations and specialty arrangements with Drawings.

D. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Ductwork."

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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.

D. 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.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

## 3.6 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.

## 3.7 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 23 36 00

# SECTION 23 37 00 – AIR OUTLETS AND INLETS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Interior Outlets and Inlets:

a. Registers, grilles, and diffusers

2. Exterior Outlets and inlets:

a. Air louvers

### 1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. Registers, Grilles, and Diffusers: Provide all supply, return and exhaust grilles, registers, and diffusers required for all systems.

### 1.4 PERFORMANCE REQUIREMENTS

A. Interior Outlets and Inlets: Provide outlets and inlets with aspiration ability, temperature mixing, and velocity traverses and decay with distance, throw, pressure drop, and noise criteria ratings equal to or better than specified products.

### 1.5 SUBMITTALS

A. Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.

B. Product Data: Submit manufacturer's product literature, technical specifications, performance data, installation instructions, and similar information required to demonstrate compliance with specified requirements. Annotate all selected options, cross referenced to specification and drawing designations. Include tabulated data for all proposed outlets and inlets, showing size, type, cfm, aspiration ability, water entrainment, temperature mixing, and velocity traverses and decay with distance, throw, pressure drop, noise criteria ratings and any other applicable data demonstrating performance equal to or better than specified products.

C. Shop Drawings: Submit shop drawings showing sizes, construction details, mounting details, capacity, and air flow characteristics for all equipment. Include complete tabulated schedules as indicated below for each of RGD, and Louvers.

1. Registers, Grilles, and Diffusers (RGD): Include complete tabulated schedule showing locations for each RGD, type, size, capacity as shown on Drawings, and performance data for each RGD furnished, including throw and noise criteria ratings. Indicate selections on data.

2. Air Louvers: Include complete tabulated schedule showing locations for each Louver showing type, size, wall and/or rough opening size, capacity as shown on Drawings, and performance data for each including pressure drop and water entrainment specifications. Include all this data on coordination drawings and special Mechanical Penetrations of General Construction Envelope coordination drawing.

D. Contract Closeout Submittals: Comply with requirements of SECTION 01 77 00, including submission of operating and maintenance instructions as item in "Operating and Maintenance Data" manual described in that section.

## PART 2 - PRODUCTS

### 2.1 REGISTERS, GRILLES, AND DIFFUSERS

A. General

1. Provide registers, grilles, and diffusers with border systems that are compatible with adjacent wall and ceiling systems, and that are specifically manufactured to fit into ceiling modules with accurate fit and adequate support. Refer to general construction drawings and specifications for details of adjacent systems.

2. All performance criteria equal to or better than design make as specified and tagged on drawings.

3. Provide factory baked white enamel finish for steel materials and clear or color anodizing for aluminum material as base bid standard finish unless otherwise specified or noted.

4. Provide products by one of the following:

a. Krueger or equal.
b. Price or equal.
c. Anemostat or equal.

B. Grilles

1. TYPE "G-A": Eggcrate return grille; 1/2 inch x1/2 inch x1inch deep squares; fabricated aluminum core; flat frame; white baked enamel finish to match ceiling. Neck size and accessories as noted on drawings. Provide frame to fit lay-in ceiling grid or hard ceiling as required. Similar to Titus 50F.

C. Supply Diffusers:

1. TYPE "D-A": Square plaque ceiling diffuser, heavy gage aluminum face panel, one piece die-stamped back pan, 1 ¼" round neck collar, #26 white finish. Flush T-bar mount to fit lay-in ceiling grid, coordinate with G.C. Similar to Titus Omni-AA.

## 2.2 AIR LOUVERS

A. Intake Louvers (Fixed Type)

1. Standard Construction Requirements:

a. Factory constructed high performance drainable (frame, blades, and head as scheduled) aluminum louvers with storm resistant blades of AMCA rated performance equal to or better than the design make.

b. Frame and blades constructed of extruded aluminum, alloy 6063-T5. Nominal wall thickness of 0.081 inches, depth to be 6 inches as noted on drawings.

c. Blade angle of 37-1/2 degrees, centered nominally at 5-3/32 inches for the 4 inch deep and at 5-29/32 inch for 6 inch deep louvers. Hidden vertical supports shall allow continuous line appearance up to 120 inches.

d. Stainless Steel 1/2 inch mesh x 0.063 inch bird screen secured in a removable frame with SS tamperproof fasteners, on exterior face of louver. Finish same as louver.

e. Extended sills constructed of aluminum, alloy 6063 – T5 with a nominal wall thickness of 0.060 inches in a style selected by Architect.

f. Provide welded construction for all factory assembled louver components. Provide stainless steel fasteners for all field assembled components.

g. Size, type and location as shown on drawings.

h. Provide scheduled factory finish as detailed below.

1) Kynar: Provide factory applied and baked resin based paint coating, minimum 70% fluoropolymer (PVDF) similar to Kynar 500 or Hylar 5000 as manufactured by the Valspar Corporation. Coating shall meet all performance requirements of AAMA 2605 and ASCA 96. Color as selected by Architect from manufacturer's full range of standard or premium colors including minimum 16 "standard" colors and 12 "premium" colors.

i. Provide products by one of the following, with performance as scheduled:

1) Greenheck Model ESD-603 or equal.
2) Similar model by Ruskin, or equal.
3) Similar model by Construction Specialties, Inc. or equal.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which air outlets and inlets are to be installed and notify a Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in an acceptable manner.

1. Air Louvers: Coordinate unit selection to meet other equipment and installation details (automatic dampers, back draft dampers, etc.). Verify all opening sizes, locations and mounting arrangements prior to installation.

### 3.2 INSTALLATION

A. Install air outlets and inlets in strict accordance with manufacturer's recommended installation instructions for applications shown on Drawings.

B. Registers, Grilles and Diffusers (RGD): Install all RGDs in accordance with manufacturer's installation instructions and SMACNA installation manual at locations indicated on Drawings.

1. Adjust each type of RGD as required to achieve even air distribution throughout occupied space, generally free of objectionable drafts and dead air pockets. Demonstrate adjustments of distribution to Owner and additionally adjust as requested by Owner's representative during or subsequent to initial adjustments. As RGD adjustment and Testing and Air Balancing work affect each other, make preliminary adjustment to all RGDs prior to balancing, and make final RGD adjustment during TAB work in cooperation with TAB agency. Refer to section 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC for more detail.

2. Provide final balancing in accordance with SECTION 23 05 93.

3. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that requires them.

C. Air Louvers: Comply with manufacturer's specifications and recommendations for assembly and installation of air louver units, hardware, operators, and other components.

1. Set units plumb, level, and true to line, without warp or rack of frames. Anchor securely in place. Separate aluminum and other corrodible metal surfaces from sources of corrosion or electrolytic action at points of contact with other materials. Use stainless steel fasteners.

2. Make suitable provision for thermal expansion in assembly of groups of units.

3. Set head, jamb, and sill members in bed of compound as shown, or with joint fillers or gaskets as shown to provide weather tight construction.

4. Provide suitable gaskets or coating where dissimilar metals are in contact.

5. Clean aluminum surfaces promptly after installation of units. Remove excess glazing and sealant compounds, dirt, and other substances.

END OF SECTION 23 37 00

# SECTION 23 63 00 – REFRIGERANT CONDENSING UNITS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Remote air-cooled condensing units.

### 1.3 SYSTEM DESCRIPTION

A. Design Requirements

1. Remote Air-Cooled Condensing Unit: Arranged for vertical airflow with fan design condensers performing as specified. Factory assembled, leak tested, evaluated, and charged with replacement holding charge. Provides maximum allowable fan outlet velocities and coil face velocities indicated in Contract Documents.

### 1.4 SUBMITTALS

A. Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.

B. Product Data: Provide manufacturer's specifications data for each unit, showing operating weight, all sizes, dimensions, capacity, operating and performance characteristics, motor horsepower, and other pertinent data. Include manufacturer's installation instructions.

1. Remote Air-cooled Condensing Unit: Indicate fan outlet velocities and coil face velocities.

C. Shop Drawings: Show on shop drawings equipment, piping connections, valves, strainers, thermostatic valves, and piping schematic required for complete system.

1. Include refrigerant piping diagram.

D. Contract Closeout Submittals: Comply with requirements of SECTION 01 77 00, including submission of operating and maintenance instructions as item in "Operating and Maintenance Data" manual described in that section.

1.5 WARRANTY

A. Manufacturer's Warranty: Standard 1-year warranty covering entire unit with 5-year parts-only warranty covering compressor and entire refrigerant circuit.

PART 2 - PRODUCTS

2.1 REMOTE AIR-COOLED CONDENSING UNIT (1 TO 10 TONS CAPACITY)

A. DU Unit Description: Self-contained, packaged, factory-assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressor(s), condensing coil and fan(s), integral sub-cooling circuit(s), filter drier(s), and controls. Refrigerant shall be R407C, R410A, or as otherwise specifically scheduled. Refer to Drawings for capacities and performance ratings.

B. Casing: 18 gauge zinc-coated galvanized steel frame and panels with weather resistant, baked enamel finish.

C. Condenser Coil: Constructed of seamless copper tubes mechanically expanded into rippled aluminum fins for permanent metal-to-metal contact and provided with full depth fin collars completely covering copper tube.

1. Copper tubes attached to headers with heavy wall fittings for maximum resistance to piping strain and vibration due to discharge gas pulsation.
2. Coils have working pressure of 450-psig with one 450-psig relief device circuit field-installed.
3. Coils factory leak-tested, dehydrated, evacuated, and sealed with holding charge of nitrogen.

D. Fan and Fan Motors:

1. Fans: Direct drive low speed propeller type with maximum rotating speed of 1200 rpm and diameter not exceeding 28 inches.

2. Fan Guards: Heavy-gauge, closed meshed, steel wire, zinc plated and iridite-dipped; contoured for maximum rigidity.

3. Fan Motors: Weatherproof motors suitable for outdoor use, with permanently lubricated totally enclosed variable speed motor, with ball bearings and built-in thermal overload protection.

E. Controls: Low ambient operating package allowing starting and operation at temperatures down to 0 deg. F., located in weatherproof enclosure, and including:

1. High pressure cut out.
2. Low pressure cut out.
3. Variable speed fan control module with head pressure feedback.
4. Compressor overload relays.
5. Liquid line temperature sensors.
6. Internal compressor winding high temperature thermostat

7. High-pressure fusible plug.
8. Oil failure cut out.
9. Five-minute anti short-cycle timer.
10. Liquid line solenoid valve installed at evaporator coil.

F. Compressors: Direct-drive hermetic, reciprocating type or scroll type compressor(s) as scheduled with capacity modulation as schedule. Modulation to below 30% capacity via variable speed driven or Copelend digital scroll technology, modulation to half capacity via two speed compressor, as scheduled. Recip: provide centrifugal oil pump providing positive lubrication to moving parts and automotive type pistons, rings to prevent gas leakage, internal suction and discharge valves and crankcase heater, and suction gas-cooled motor with internal temperature and current sensitive motor overloads internally isolated on springs and equipped with external high and low pressure cutout devices.

G. Accessories - All units provided with:

1. Filter dryer
2. Liquid line solenoid valve
3. Sight glass
4. Suction and liquid line refrigerant service valves
5. Neoprene vibration isolators per manufactures recommendations

H. 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. Design Manufacturer: Trane.

2. Specified equivalents:

a. Daiken or equal.
b. Lennox or equal.
c. Trane or equal.
d. York or equal.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which refrigerant condensing units are to be installed in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in an acceptable manner.

1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Architect written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.

## 3.2 INSTALLATION

A. Install Remote Air-Cooled Condensing Units in strict accordance with manufacturer's recommendations as required providing a complete and properly operable system, and as follows.

B. Provide proper roof mounted supports:

1. Units 3 ton capacity and smaller: provide combination equipment / piping curb in proper position on roof, secured and leveled as recommended by manufacturer. Provide sufficient portals in pipe penetration portion of curb for refrigerant, electrical power, and control wiring.

C. Provide all refrigerant piping as specified in section 23 23 00 – Refrigerant Piping, and as additionally recommended by condensing unit manufacturer.

D. Provide all required supports, attachment devices, vibration isolators, gasketing, sealants, and accessories needed to insure stable, quiet, leak free operation.

## 3.3 FACTORY START UP AND FIELD QUALITY CONTROL

A. Provide authorized factory representative to start-up unit, check following items, and furnish report:

1. Proper connection of all power and ground wiring.

2. Measure and check voltage of components.

3. All wiring circuits.

4. Check removal of shipping bracing.

5. Check control circuitry, operation, and performance during all modes of operation.

6. Fan check (RPM, motor amps, rotation, belt tension, etc.).

7. Check all refrigerant piping, refrigerant charge, operating temperatures and pressures, superheat, sub-cooling, condition and location of specialties including isolation valves, charging ports, dryers, filters, etc.

8. All accessory equipment operation, such as filters, controls, etc.

END OF SECTION 23 63 00

# SECTION 23 74 00 - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Single zone Energy Recovery Units.
2. Multi-zone Energy Recovery Units.

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.4 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data for each UNIT, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. 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.

### 1.5 INFORMATIONAL SUBMITTALS

A. 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 ERUs will be attached.
2. Roof openings.
3. Roof curbs and flashing.

B. Warranty: Special warranty specified in this Section.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For Units to include in emergency, operation, and maintenance manuals.
B. Warranty: Executed special warranty specified in this Section.

## 1.7 QUALITY ASSURANCE

A. AHRI Compliance:

1. Comply with AHRI 210/240 and AHRI 340/360 for testing and rating energy efficiencies.
2. Comply with AHRI 270 for testing and rating sound performance.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Staunitp."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. 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.

## 1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

## 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. Filters: Three sets of filters for each unit.

# PART 2 - PRODUCTS

## 2.1 SINGLE ZONE VOLUME ENERGY RECOVERY UNITS

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. AAON, Inc.
2. Addison Products Company.
3. Carrier Corporation.
4. Engineered Air.
5. Lennox Industries Inc.
6. McQuay International.
7. Trane; American Standard Companies, Inc.
8. YORK International Corporation.

B. General Description

1. Packaged rooftop unit shall include compressor, evaporator coil, filters, supply fan, dampers, air-cooled condenser coils, condenser fan, gas heater, energy recovery wheel, exhaust fan and unit controls.

2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment’s literature pocket.

3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

4. Unit components shall be labeled, including refrigeration system components and electrical and controls components.

5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

6. Installation, Operation and Maintenance manual shall be supplied within the unit.

7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s hinged access door.

8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s hinged access door.

C. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F.

3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.

4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 210/240. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

6. Access to filters, dampers, cooling coil, gas furnace, compressor, and electrical and controls components shall be through hinged access doors with quarter turn, lockable handles. Full length stainless steel piano hinges shall be included on the doors.

7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

8. Units shall include double sloped 304 stainless steel drain pans.

9. Unit shall be provided with through the base vertical discharge and return air openings. All openings through the unit shall have upturned flanges of at least 1/2 inch around the opening.

10. Unit shall include lifting lugs on the top of the unit.

11. Unit base pan shall be provided with 1/2 inch thick foam insulation.

D. Electrical

1. Unit shall have a 5kAIC SCCR.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

3. Unit shall be provided with a factory installed and factory wired 115V, 12 amp GFI outlet disconnect switch in the unit control panel.

E. Supply and Exhaust Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply and exhaust fans.
2. Blowers and motors shall be dynamically balanced.
3. Motor shall be inverter rated efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Variable frequency drive shall be factory wired and mounted in the unit. Fan motor shall be inverter rated efficiency.

F. Cooling Coils

1. Evaporator Coils

a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

b. Coil shall be standard capacity.

c. Coils shall be helium hydrogen or helium leak tested.

d. Coils shall be furnished with factory installed thermostatic expansion valves.

G. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant.

2. Compressors shall be scroll type with thermal overload protection and carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.

3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.

4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

5. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.

6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed liquid line filter driers.

7. Unit shall include a variable capacity scroll compressor on the refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.

8. Refrigeration circuit shall be equipped with a liquid line sight glass.

9. Refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

H. Condensers

1. Air-Cooled Condenser

a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.

b. Coils shall be designed for use with R-410A refrigerant.

c. Condenser coils shall be multi-pass and fabricated from aluminum microchannel tubes.

d. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

e. Coils shall be hydrogen or helium leak tested.

f. Condenser fans shall be high efficiency electrically commutated motor driven with multiple speeds which are controlled with a fan cycle switch based on head pressure and allow matching condenser airflow with cooling capacity steps.

I. Gas Heating

1. Stainless steel heat exchanger furnace shall carry a 25 year non-prorated warranty, from the date of original equipment shipment from the factory.

2. Gas furnace shall consist of stainless steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.

3. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.

4. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.

5. High Turndown Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet. Heat trace shall be include on the condensate drain line.

J. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. Unit shall contain factory mounted and tested energy recovery wheels. The energy recovery wheels shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

3. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

4. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

5. Unit shall include 2 inch thick, pleated panel outside air and exhaust air filters with an ASHRAE MERV rating of 8, upstream of the wheels.

6. Hinged service access doors shall allow access to the wheel.

7. Unit shall include energy recovery wheel defrost control which includes an adjustable temperature sensor and timer wired to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel.

8. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

    a. Aluminum Energy Recovery Wheels

        1) Unit shall contain a factory mounted and tested monolithic aluminum energy recovery wheel with an inverter duty motor and a durable segmented link drive belt composite. Wheel frame shall be constructed with prime G90 hot-dip galvanized steel tested for corrosion resistance of 400 hours of salt spray.

        2) Aluminum Energy recovery wheel shall be covered under the standard AAON limited parts warranty; the first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts.

3) Sensible energy recovery wheels shall be made of corrugated aluminum and not coated. Segments shall be cleanable with hot water or compressed air.

K. Filters

1. Unit shall include 4 inch thick, pleated panel filters with an ASHRAE MERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4 inch standard filters.

L. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Unit shall include outside air opening bird screen, outside air hood with rain lip and motorized exhaust air damper.

M. Controls

1. Factory installed and factory provided controller with BACnet integration to building management system.

a. Unit controller shall be capable of controlling all features and options of the unit required to achieve the sequence of operation. Controller shall be factory installed in the unit controls compartment and factory tested.

b. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad.

c. Controller shall be capable of communicating and integrating with the building management system BACnet network.

d. Primary control shall be achieved via the building management system but the controller shall be capable of standalone operation to achieve the sequence of operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available.

e. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.

f. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.

g. Control component devices not available as a factory option shall be field provided. Refer to section 23 09 00 Instrumentation and Control for HVAC for additional information.

h. Control components shipped loose shall be installed by the Contractor.

N. Accessories

1. Unit shall be provided with a safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

O. Roof Curb

1. Curbs shall be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.

2. 24” high solid bottom curb shall be factory assembled and fully lined with curb rated 1 inch fiberglass insulation and include a wood nailer strip.

## 2.2 MULTI-ZONE ENERGY RECOVERY ROOFTOP UNITS

A. General Description

1. Replacement HVAC units shall be specifically designed, engineered and manufactured for exact replacement. Units shall be factory manufactured for installation on new roof curb without the use of a curb adapter, transitions or modifications to the existing ductwork.

2. Units shall be run tested at factory and operation of all functions, safeties, devices, etc, shall be verified. Operational test sheets shall be provided upon request. Units shall be ETL listed as a complete unit and shall bear the ETL label. All parts shall be available at the local wholesaler level, therefore no OEM parts will be allowed

B. Warranty

1. Unit(s) shall be provided with one (1) year parts warranty, and fifteen (15) year cabinet warranty. Labor warranty, if any, provided by Contractor.

C. Quality Assurance

1. Unless otherwise specified or indicated, all materials and equipment shall be the products of a manufacturer regularly engaged in the production of heating, ventilation and air conditioning materials and equipment. Manufacturer shall have a minimum of five (5) years experience in the production of their product.

2. All units to be factory run tested before shipping.

3. Unit(s) shall bear the ETL label, tested in accordance to UL 1995.

4. NFPA 70

D. Delivery, Storage and Handling

1. Units shall match the existing roof openings and supply duct connections without the use of a curb adapter, transitions, or modifications to the roof support. The use of curb adapters is not acceptable. Roof curb gasket shall be provided and shipped loose with the unit. Units shall match existing duct connections and require minimal field time to reconnect and seal. Units shall match existing utility and electrical power connections as close as possible and shall require only minimal field time to reconnect.

2. Prior to fabrication of the equipment, a factory engineer shall visit the jobsite, measure the existing units, and become familiar with the exact requirements of the project. A local manufacturer's representative shall not be considered as a substitute. A factory trained technician shall be present for start-up and rigging assistance and will submit a check test start-up report after field installation and start-up.

E. Construction

1. Replacement roof mounted packaged air conditioning units manufactured by SEASONS - 4 or Engineer approved equal with dimensions, capacities and electrical characteristics to match that of the existing Nesbitt units shall be provided. The equipment must comply with the requirements and terms of ETL's Listing, Labeling and Follow-up Service Agreement and the complete unit must bear the ETL Label.

2. The replacement unit must comply with the ventilation standards as listed on the equipment schedule. Therefore, the specified unit may be slightly higher, wider, or longer than the unit being replaced. The new replacement unit must be designed to match the existing roof opening, number of zones, and avoid obstructions adjacent to the unit being replaced. The new unit shall be designed to provide a minimum interior height of 56" and full height access doors on the fan, filters, and coil sections for ease of maintenance.

3. Manufacturers of proposed substitute equipment must send a technician to the jobsite. During the manufacturer's visit, the old unit's ducts must be measured, the location of the utilities determined, and obstructions adjacent to the unit must be noted. A preliminary set of equipment submittals shall be attached to the substitution request.

4. Base Frame:

   a. The unit frame shall be constructed of heavy gauge galvanized steel with a formed galvanized steel base. Lifting lugs shall be welded on the base frame for rigging the unit.

5. Cabinet Panels, Roof, Floor:

   a. All exterior panels must be fabricated from pre-painted embossed aluminum alloy. The color finish is to be Kynar Cadet Gray for increased corrosion protection (salt spray test 3,000 hrs).

b. Aluminum panels shall be fastened to the frame with stainless steel screws. Panels must be isolated from the steel frame with dielectric gaskets to prevent galvanic corrosion. The roof of the unit must be pitched to provide positive drainage. Top seams must be covered with cap strips to prevent water leakage into the unit and the floor of each section shall have a galvanized or aluminum steel deck to isolate the entire unit from the building. All seams must be caulked with silicone inside and out to prevent air and water leakage.

c. All walls, roof, and doors in the air-handling compartment shall be double wall construction enclosing 2" thick polyurethane foam insulation. Aluminum or galvanized internal liners shall be utilized to protect the insulation during routine service and maintenance operations. The floor of the air handling sections must be insulated underneath with 2" thick polyurethane foam insulation. Insulation should have a minimum R-value of R-13. Single wall unit construction or exposed insulation is not acceptable.

6. Doors:

a. Access doors must be provided for all sections that house components requiring routine maintenance. Door materials and construction shall be the same as the cabinet panels. Doors shall be supported on piano style aluminum hinges and have and have single handle, multiple latch closures. Access doors shall have stainless steel "hold back" latches to prevent door closure during the performance of service procedures. When obstructions on the roof will interfere with access doors, provide lift off panels held in place by a minimum of four Allegis nylon cam action handles.

b. All doors in the air handling section shall open against the pressure or shall include an additional number of latches equal to 50% of the number of latches used on the same size doors that open with the pressure.

7. Coils:

a. Units to feature a dual temp water coil. Dual temp water coil must be installed downstream of the supply air blower. Coil shall be constructed of seamless copper tubes expanded into aluminum fins and encased in a galvanized coil casing.

b. For control valves and valve operators refer to 23 09 00 Instrumentation and Controls for HVAC.

c. Each coil shall be provided with a positive draining IAQ type double pitched, stainless steel drain pan. The drain for the main drain pan must be metal and extend through the side of the unit.

8. Multi-Zone Damper Section Double Deck:

    a. Unit shall have factory mounted multi-zone dampers in the hot and cold deck. Dampers must be linked together to provide individual zone control with factory mounted and wired operators. Each cold deck blade shall have similar but opposite acting hot deck blade. The cold deck and hot deck must be separated by a double wall insulated divider. Damper shafts shall be mounted in permanently lubricated nylon bearings to assure smooth operation. Damper blades must operate without clatter or binding.

9. Supply Air Blower Section (Direct Drive w/VSD:

    a. The supply air blower is direct-drive single width/single inlet airfoil plenum type, arrangement 4, with a tapered bushing. Motors are premium efficiency heavy-duty open drip proof 3-phase, mounted on a heavy-duty base. The standard construction for the wheels and cones will be powder coated steel. Motor and blower assembly are mounted on a powder coated heavy-duty steel frame supported by 2" spring isolators designed for 90-98% isolation efficiency. The complete blower assembly is dynamically balanced and AMCA Certified. In addition to the spring isolators, the blower assembly has seismic restraints. The blower speed shall be controlled by a Variable Speed Drive as specified below.

    b. Blower speed shall be controlled by a Variable Speed Drive (VSD) housed in a U.L. listed NEMA 1 enclosure, factory mounted and wired in the unit. The drive must include line side reactors. The drive shall have an advanced microprocessor type utilizing a PWM/Voltage Vector design technique. Unit shall include controls to provide variable air volume and maintain constant static pressure at the factory mounted pressure sensor in the supply air plenum. A manually reset adjustable range high-pressure safety switch shall be included to prevent excessive pressure in the supply duct. In addition to the spring isolators, the blower assembly has seismic restraints.

    c. Variable Speed Drives shall be ABB model ACH850.

10. Exhaust Air Blower Section (Direct Drive w/VSD):

    a. The exhaust air blower is direct-drive single width/single inlet airfoil plenum type, arrangement 4, with a tapered bushing. Motors are premium efficiency heavy-duty open drip proof 3-phase, mounted on a heavy-duty base. The standard construction for the wheels and cones will be powder coated steel. Motor and blower assembly are mounted on a powder coated heavy-duty steel frame supported by 2" spring isolators designed for 90-98% isolation efficiency. The complete blower assembly is dynamically balanced and AMCA Certified. In addition to the spring isolators, the blower assembly has seismic restraints. The blower speed shall be controlled by a Variable Speed Drive as specified below.

b. Blower speed shall be controlled by a Variable Speed Drive (VSD) housed in a U.L. listed NEMA 1 enclosure, factory mounted and wired in the unit. The drive must include line side reactors. The drive shall have an advanced microprocessor type utilizing a PWM/Voltage Vector design technique. Unit shall include controls to provide variable air volume and maintain constant static pressure at the factory mounted pressure sensor in the supply air plenum. A manually reset adjustable range high-pressure safety switch shall be included to prevent excessive pressure in the supply duct. In addition to the spring isolators, the blower assembly has seismic restraints.

c. Variable Speed Drives shall be ABB model ACH850.

11. Variable Speed Drive Section:

a. VSD Manufacturer

1) ABB
2) Yaskawa

b. Unit fan motors shall be provided with solid state Variable Speed Drives to convert three phase, 60 Hz power to adjustable frequency and voltage three phase power for step less motor speed control from 0% to 100% of base speed. Input voltage shall be same as the unit voltage. The VSD shall be capable of operating within the range of 10% over to 10% under the rated input voltage. The VSD shall be designed for use on variable torque loads and shall be capable of providing sufficient torque to start motor from rest with initial influx of power.

c. The VSD operation shall be fully factory tested by the drive manufacturer prior to shipment and installation. The VSD controller shall have the following features: isolated power for control circuits, automatic type reset faults for over-current, under-voltage, over-voltage, phase loss or over-temperature, fault counter reset, adjustable current limiting circuitry, independent acceleration and deceleration time adjustment, 4-20 mA or 0-10Vdc control signal interface, 4-20 mA output signal, and automatic frequency adjustment. VSD shall be provided with digital read output meter indicating percent speed and load, local/remote selector switch, power/on, diagnostic, and fault trip indicating lights, Hands/Off/Auto selector switch, and manual speed control adjustment. The complete drive shall be tested to ANSI C37.90.1 and UL Standard 508 and be ETL or UL listed. Power line noise distortion shall be limited to voltage distortion factor and line notch depth as defined in IEEE Standard 519-1981. Total voltage distortion shall not exceed 5%. VSD shall be provided 3 form “C” relay contacts

12. Shaft Grounding Rings:

a. Whenever variable speed PWM drives are installed to control AC motors, maintenance free, circumferential, conductive micro fiber shaft grounding brush shall be installed on the AC motor to discharge shaft currents to ground.

13. Energy Recovery Section (Total Energy Wheel):

    a. Total Energy Recovery Type shall be comprised of aluminum coated with 4A Molecular Sieve, non-migrating, water selective desiccant. Aluminum base material shall be a minimum of 70 microns (0.0027") thick hardened aluminum alloy. Including coating, material shall not be less than 14 LBS/FT3 and media wall thickness shall not be les than 0.005". Media shall be corrugated with a flute height of 1.5 mm (0.091") and flute width of 3.0 mm (0.118"), allowing for passage of 800 micron particles, and shall be rated to withstand intermittent exposure to 250 FDB without loss of performance or reduction in structural integrity. Media may be cleaned with mild detergent, water, compressed air, or low pressure steam (< 15 PSI). Rated lifetime shall not be less than 87,600 hours, and shall be defined by media performance < 90% of original capacity. Rotor performance shall be independently tested in accordance with applicable ASHRAE guidelines (Method of Test 84-91), and rated in accordance with ARI Rating Method 1060. Flame resistance and smoke produced indices must also be independently tested in accordance with ASTM E-84 with results of less than 25/50.

    b. Rotor frame shall be comprised of a solid aluminum center hub with internal 12 mm diameter spokes, welded to an outer aluminum band to provide for rigid unitized construction.

    c. Rotor bearings shall include internal mounted 100,000 hour rated sealed, non maintenance, spherical ball bearings. Bearings shall be additionally protected by a galvanized steel dust shield (Hub Plate). Included carbon steel shaft secures the rotor axially by means of two (2) oversized snap rings.

    d. Cassette Frame shall include formed galvanized steel face panels with sheet metal connectors, and a "cross" shaped coated carbon steel post sub assembly at each face for mounting in multiple airflow positions. Wheel position is adjusted manually with an included post mounted jacking mechanism at each face. Purge shall be either fixed or fully adjustable, per application requirement.

    e. Rotor Seals pressure shall be multiple pass with four (4) layers at each of the perimeter and cross sealing locations. Material shall be polypropylene with brush outer layers and wiper style inner layers. Seals may be adjusted for either contact location (maximum sealing) or non contact locations (minimum turning resistance of the wheel) per application.

    f. Rotor Drive shall be via a 1/2 HP, right angle drive motor, equipped with a cast iron fixed diameter drive pulley. Motor shall be mounted to an adjustable spring tensioned galvanized steel base plate face. Drive system shall include a fabric reinforced, urethane coated, perforated V-belt.

14. Main Filters:

    a. The filter section shall include UL Class 2, 4" thick, MERV-13 efficiency panel type filters. Access for filter maintenance shall be through a full height service door on the side of the unit. Filter support rails must include slide out "pulls" to facilitate removal of the filters.

15. Exhaust and Outside Air Filters:

    a. The filter section shall include UL Class 2, 2" thick, MERV-8 efficiency panel type filters. Access for filter maintenance shall be through a full height service door on the side of the unit. Filter support rails must include slide out "pulls" to facilitate removal of the filters.

16. Economizer Section:

    a. The unit shall have an outside air intake on one side of the unit and an exhaust air discharge on the opposite side. Outside air and exhaust air openings on the same side of the unit are not acceptable. Outside air intake shall have storm-proof louvers or hoods sized to prevent entrainment of rainwater into the unit and must include an aluminum bird screen.

17. Dampers:

    a. Dampers shall have factory-mounted operators. Damper shafts shall be mounted in permanently lubricated nylon bearings to assure smooth operation. Damper blades must operate without clatter or binding and be of airfoil design. Motorized dampers shall be low leakage type limiting leakage to 6 CFM/ft2 at a pressure differential of 4 inches.

18. Main Control Panel:

    a. The unit shall have a single point electrical power connection in the same location as the unit being replaced. The new unit must be able to utilize the same power wiring as the unit being replaced. The main control panel must include a disconnect switch mounted in a weatherproof enclosure (NEMA 3R equivalent) on the side or the end of the unit.

    b. All components shall be identified with nametags and wired in accordance with the National Electric Code. The main control panel must include the following:

        1) A terminal block for single point power supply with fuses for all branch circuits.

        2) A 24-volt control transformer and 24-volt field wiring control terminal strip. Terminals shall be numbered for field connection of all controls in accordance with the wiring diagram.

        3) All wiring must be numbered and color-coded.

4) A phase failure and low voltage protection relay.

5) Temperature control components as required for the system described below in the "Temperature Control Sequence".

6) Wiring diagrams must be laminated to the control panel door.

7) A service light with switch and a 115 volt 10-amp ground fault convenience outlet factory mounted and wired to its own transformers.

8) Fan motor starters with three-phase overloads factory mounted and wired.

9) The above components are in addition to electrical components associated with other sections required to accomplish the sequence of operations.

19. Temperature Controls:

a. Unit shall have a complete factory installed DDC temperature control system provided by controls contractor and installed at unit manufacturer. The control contractor is responsible of control of the cooling and heating, new room temperature controls, and economizer controls. Damper operators provided by the unit manufacturer. The DDC control must be capable of Lon, BACnet, Modbus and N2 protocols for future interface with the building management system. The controls contractor is responsible for programming the DDC controller.

b. It is the Owner's intent to establish a fully compatible and interoperable Energy Management and Control System (EMCS) network as an extension of the Lakeland's School District's distributed Technical Building Services (TBS) EMCS. The existing front end control system is a Tridium by Schneider Electric-I/A Series. For more information contact Jason Kross (518) 312-6086 at Technical Building Services, Inc. a Stark Tech Company.

c. The unit must be designed for continuous blower operation and must include terminals for field connection to a building operating system, to be provided by the temperature control contractor

20. Other Controls:

a. Unit must have terminal strips and interlocking relays factory mounted and wired to interlock with other components of the building. It is the responsibility of the control contractor to advise the HVAC unit manufacturer of any requirement for any additional interlocks not covered in this specification.

b. Provide a photoelectric type smoke detector mounted and wired in the supply and return section to the unit. Upon detection of smoke, fans shall stop and a signal must be sent to the building fire alarm system.

c. Provide a Magnehelic differential pressure gauge for each bank of filters. Filters shown back to back (such as prefilter/main filter combo) will have one gauge reading the total pressure drop. Gauge shall be mounted in the main unit control panel.

21. Curb:

a. Furnish a 24” high, canted curb. Curb shall be full perimeter and supports as required for the unit. Curb shall be constructed of galvanized steel and wood blocking, be insulated, and allow for field flashing to the curb. Curb provided with a gasket for field installation.

22. Field Services:

a. Prior to Fabrication: The manufacturer must send a factory engineer to the job site to measure and document the existing units. A local factory representative does not comply with this requirement.

b. Installation: The manufacturer must send an installation expert to the jobsite to advise on proper rigging and alignment of the equipment. The installing contractor should become familiar with the manufacturer's rigging and installation instructions.

c. Check, Test, Staunitp: Unit must be checked out, tested, and placed into operation by the installing contractor under the supervision of an authorized representative of the factory.

## 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 units.
B. Examine roughing-in for Units to verify actual locations of piping and duct connections before equipment installation.
C. Examine roofs for suitable conditions where Units will be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.
E. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

### 3.2 INSTALLATION

A. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified elsewhere. Secure Units to upper curb rail, and secure curb base to roof framing with anchor bolts.

### 3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Connect supply ducts to Units with flexible duct connectors specified in Division 23 Section "Ductwork."

## 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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

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. Report results in writing.

2. After installing Units and after electrical circuitry has been energized, test units for compliance with requirements.

3. Inspect for and remove shipping bolts, blocks, and tie-down straps.

4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

## 3.5 START UP SERVICE

A. Engage a factory-authorized service representative to perform start up service.

B. Complete installation and start up 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 furnace combustion chamber.

3. Inspect for visible damage to compressor, coils, and fans.

4. Inspect internal insulation.

5. Verify that labels are clearly visible.

6. Verify that clearances have been provided for servicing.

7. Verify that controls are connected and operable.

8. Verify that filters are installed.

9. Clean condenser coil and inspect for construction debris.

10. Clean furnace flue and inspect for construction debris.

11. Connect and purge gas line.

12. Remove packing from vibration isolators.

13. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

14. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete start up sheets and attach copy with Contractor's start up report.

15. Inspect and record performance of interlocks and protective devices; verify sequences.

16. Operate unit for an initial period as recommended or required by manufacturer.

17. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.

    a. Measure gas pressure on manifold.
    b. Inspect operation of power vents.
    c. Measure combustion-air temperature at inlet to combustion chamber.
    d. Measure flue-gas temperature at furnace discharge.
    e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

18. Calibrate thermostats.

19. Adjust and inspect high-temperature limits.

20. Inspect dampers for proper stroke.

21. After start up and performance testing and prior to Substantial Completion, replace existing filters with new filters.

## 3.6 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 visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing UNIT and air-distribution systems, clean filter housings and install new filters.

## 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 74 00

# SECTION 23 82 00 – TERMINAL HEATING AND COOLING UNITS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following types of Terminal Heating and Cooling Equipment, associated accessories, and their installation:

1. Unit Ventilators (UV)
2. Fan-Coil Units (FCU)
3. Fin Tube Radiation (FTR)

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.

B. 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 anchorages and attachments to structure and to supported equipment.
3. Wiring Diagrams: Power, signal, and control wiring.

### 1.5 CLOSEOUT SUBMITTALS

A. Field quality-control test reports.

B. Operation and Maintenance Data: For unit ventilators blower-coil units, fan-coil units, convectors, fin tube radiation, unit heaters, and air coils to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

C. Warranty: Executed special warranty specified in this Section.

## 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.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## 1.7 COORDINATION

A. Coordinate layout and installation of all units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake and relief dampers.

## 1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Compressor failure.
   b. Condenser coil leak.

2. Warranty Period: 10 years from date of Substantial Completion.

3. Warranty Period (Compressor Only): 5 years from date of Substantial Completion.

4. Warranty Period (Condenser Coil Only): 5 years from date of Substantial Completion.

## 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. Unit Ventilator Filters: Furnish three spare filter(s) for each filter installed.
2. Fan-Coil Filters: Furnish three spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 UNIT VENTILATORS

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. Carrier Corporation.
2. Daikin.
3. Magic Aire
4. Nesbitt Aire, Inc.
5. Trane.

B. Description: Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995, including finished cabinet, dampers, filter, heating and cooling coil, drain pan, supply-air fan and motor in draw-through configuration.

C. Provide Unit Ventilators constructed to operate quietly in an exposed classroom environment. Cabinet construction, fan speed and quality, and system insulation shall all combine to create units that operate with sound levels that do not exceed those shown below.

| **Unit Size** | **Motor Speed** | **SOUND POWER DATA (db re: $10^{-12}$ watts)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Octave Band:* | | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| *Center Frequency:* | | *125* | *250* | *500* | *1000* | *2000* | *4000* | *8000* |
| a. 750 | High | 57.4 | 51.8 | 52.5 | 52.6 | 51.2 | 46.9 | 35.2 |
| b. 750 | Medium | 50.1 | 44.9 | 45.6 | 44.8 | 42.8 | 34.2 | 19.9 |
| c. 750 | Low | 45.6 | 40.4 | 40.8 | 39.1 | 35.7 | 24.4 | 12.0 |
| d. 1000 | High | 57.0 | 52.8 | 53.9 | 53.7 | 51.5 | 46.8 | 35.9 |
| e. 1000 | Medium | 52.9 | 48.6 | 50.2 | 49.6 | 46.5 | 40.1 | 27.9 |
| f. 1000 | Low | 49.4 | 45.4 | 47.0 | 45.5 | 42.0 | 33.6 | 20.7 |
| g. 1250 | High | 62.4 | 55.2 | 55.7 | 55.3 | 54.4 | 49.7 | 38.5 |
| h. 1250 | Medium | 59.3 | 52.1 | 52.5 | 51.7 | 50.4 | 44.0 | 31.8 |
| i. 1250 | Low | 55.6 | 48.6 | 49.1 | 47.2 | 45.6 | 37.1 | 24.0 |
| j. 1500 | High | 63.8 | 56.6 | 58.0 | 58.2 | 56.4 | 52.4 | 41.9 |
| k. 1500 | Medium | 58.4 | 51.3 | 52.7 | 52.4 | 49.5 | 43.5 | 30.5 |
| l. 1500 | Low | 54.8 | 47.6 | 49.4 | 47.5 | 44.2 | 36.2 | 21.5 |

D. Cabinets

1. Frames: jig welded of heavy gauge steel to insure proper durability, dimensions, and squareness.

2. Finish: sheet metal parts of G-90 galvanized steel to inhibit corrosion, exterior cabinet panels fabricated from 16-ga. Furniture grade galvanized steel, cleaned and phosphatized before applying a baked on polyester powder coat enamel finish. Finish color to be selected by Architect from manufacturer's standard colors.

3. Insulation: Minimum 1-inch thick, matte-finish, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

    a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

    b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in NFPA 90.1 and ASHRAE 62.1.

4. Service Access:

    a. Opening or removing the unit front control and service panels shall not affect unit operation, allowing controls and damper linkage adjustments while the unit is running.

    b. Provide hex-head fasteners designed for repeated use to secure all removable panels.

5. Provide heating only units with coil mounting configuration and drain pan such that the later addition of a cooling coil requires no chassis modification.

E. Floor Units:

1. Provide with three separate removable front panels configured so that it is not necessary to remove the entire unit front cover or disturb the airflow to gain access to the service and control compartments.

2. Provide an integral closed rear pipe tunnel for convenient crossover of piping or electrical wiring in accordance with NEC.

3. Provide with supply discharge grille of continuous round edged steel bars with 10 to 15 degree vertical deflection and adjustable side deflection vanes beneath the discharge grille.

4. Return-Air Inlet: Front toe space where shown with no casework, draft stop deflector panel with rear side panel openings where shown with abutting casework or draft stop enclosure, or as otherwise scheduled.

5. End Panels: Provide where units are shown without UV manufacturer's new abutting casework, in material and finish matching unit ventilator.

    a. Provide formed steel end panels nominally 1" deep where no connecting casework obstructs side access, and where UVs are shown with new abutting millwork casework.

    b. Provide single thickness 16-ga. sheet steel panels where existing casework or general construction obstructs space available for unit.

    c. Provide custom depth end panel extensions as required to infill space between existing casework and new smaller unit ventilator, and as required to provide adequate service access for as specified piping.

6. Provide 1/4” mesh screen beneath the discharge grille to protect against objects being dropped through the discharge grille.

7. Provide leveling legs to compensate for uneven floor surfaces.

8. Provide adaptor back units (21-7/8") consisting of standard depth unit plus approximately five inch deep insulated false back outside air intake plenum wherever manufacturer’s standard size OA intake opening in general construction is not directly aligned with unit OA intake and unless standard depth units are specifically called for.

    a. Provide insulation on the rear of the basic unit same as the standard depth unit.

    b. Include full back panel with field cut flanged opening to match wall opening.

    c. Provide dual closed cell foam gasket at rear of the adaptor back as required to provide air tight seal round the wall opening and the unit perimeter when the unit is lagged to the wall.

    d. Insulation:

        1) Provide R-6 minimum, matte-finish closed-cell foam insulation, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916. Insulate outside air duct on bottom, side, and top walls of adapter back and pipe tunnel as thermal break between outside air intake plenum and occupied space / return air / pipe space.

        2) Fire-Hazard Classification: Insulation and adhesive combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

        3) Surfaces in contact with the airstream: Comply with requirements in ASHRAE 62.1.

9. Color for selection by the Architect.

F. Coils:

1. Test and rate unit ventilator coils according to ASHRAE 33.

2. Provide hydronic coils of self-venting design with rows as required by scheduled capacity rated for a minimum working pressure of 200 psig at no less than 220 deg F. Elements of not less than 3/8" seamless copper tubes and return bends on staggered centers in the direction of air flow. Fins of continuous plate aluminum mechanically bonded to all tubes no closer than 0.1 inch. Provide with 7/8" silver brazed copper headers with minimum 4 pass serpentine design and NPT threaded connections as required to achieve a water pressure drop no greater than scheduled. Provide threaded drain plug at low point, and manual air vent at coil high point.

3. Coil Accessories:

    a. Provide a factory installed automatic reset freeze-stat (refer to section 23 09 00 for specification) serpentined across the discharge face of the coil. Install tautly extended across and in close proximity to representative areas of coil as required to insure and guarantee against coil freeze-up conditions without freeze-stat nuisance trip.

G. Dampers

1. Provide with factory mounted air dampers.

    a. Damper shaft extends through bearings to service compartment designed to accept electronic damper actuator.
    b. Bearings of high-performance polymer similar to delrin which does not require lubrication.
    c. Seals along edges of formed damper blade material fitted into channel with blended silicone rubber and mohair impregnated glass cloth, with mohair seals along all ends.

2. Outdoor air damper: two-piece double wall torsionally rigid box beam construction with 1/2" thick, 1.5pcf density fiberglass sandwiched between welded 20-ga. galvanized steel blades. Provide additional closed cell foam insulation adhered to the interior and exterior of the outside air dampers and all other surfaces of the outside air chamber, minimum R value of 4.

3. Comply with ASHRAE/IESNA 90.1.

H. Indoor Fan and Motor Assembly

1. Direct drive multiple fan and motor assembly constructed to assure quiet, uniform air distribution, guaranteed to deliver the unit's nominal advertised cfm at high speed.

2. All components of the fan/motor assembly including the motor mounting platform mounted on a chassis removable as a single subassembly from the front of the unit.

3. Fans wheels statically and dynamically balanced, constructed of welded galvanized steel or dark, high density, injection molded fiber reinforced polypropylene having high impact strength, chemical resistance and thermal stability. Fan housings constructed of welded galvanized steel, with deep spun bell-mouth entries.

4. Single full length large diameter hollow steel shaft on resiliently mounted precision shaft end sleeve type bearings. Bearings require oiling no more than annually, located outside of the moving air stream with no intermediate bearings allowed.

5. Motors designed specifically for extra quiet unit ventilator operation, 115 volts, single phase 60 Hz unless otherwise scheduled.

a. Automatic speed control motors: electronically commutated motor (ECM) as manufactured by General Electric. Motor shall be of permanent magnet, brushless DC premium efficiency design with variable speed electronic controller capable of maintaining constant speed, torque, and/or cfm as required by service, capable of accepting 0-10vdc or 4-20mA speed control signal from building management system. Adjustable slow start and gradual speed changes, permanently lubricated ball bearings, and extra quiet operation are all included.

I. Unit Electrical and Controls

1. Provide unit mounted integral disconnect and control boxes with ample room for installing and servicing controllers, control circuit fusing, room air fan speed terminal contacts for ECM motor control by DDC control system, speed selector switch as applicable, freeze-stat switch body, transformers, and fused 120vac duplex outlet. Arrange all electrical components for ease of serviceability.

2. Provide fan motor and controls voltage power transformers for units where power source is other than fan and/or controls voltage.

3. Provide additional fused 120vac duplex outlet, to be available for power supply to control components and for servicing. Wire this outlet receptacle so that whenever the unit ventilator fan power disconnect is turned off, power is still supplied to this controls power outlet. Provide warning signage at receptacle stating it has power when disconnect is off, or, provide second disconnect.

4. Additional control devices and operational sequences are specified in Division 23 Section "Instrumentation and Control for HVAC" and on the drawings.

J. Accessories

## 2.2 DUCTED FAN-COIL UNITS

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. Carrier Corporation.
2. Environmental Technologies, Inc.
3. McQuay International.
4. Trane.
5. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1-inch thick foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Drain Pans: Insulated galvanized steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.

E. Chassis: Galvanized steel.

F. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 8 MERV.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

H. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

I. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

J. Remote condensing units are specified in Division 23 Section "Refrigerant Condensing Units."

K. Control devices and operational sequence are specified in Division 23 Section "Instrumentation and Control for HVAC".

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

## 2.3 HOT-WATER FINNED TUBE RADIATORS

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. Rittling, a div. of Hydro-Air Components.
2. Slant/Fin.
3. Sterling Hydronics, a Mestek company.

B. Performance Ratings: Rate baseboard radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."

C. Fin Radiation: Complete enclosure of heavy-duty, institutional grade construction, continuous supporting channel and back plate, heating element, hangers and accessories as required; factory-boxed and tagged by room number and securely anchored to building in a manufacturers approved manner. Enclosures to run from wall-to-wall, unless otherwise indicated on Drawings, and provided with all necessary corner pieces, end caps, column enclosures, butt joint trims, wall sleeves, and all access doors required.

1. Heating Elements:

    a. Element constructed of seamless drawn copper tubing mechanically expanded into aluminum full collar or full temper embedded fins of size shown and specified.
    b. Provide tube size 3/4" through 1-1/4" as required by flow rate. Use same fin tube element tube size as pipe size shown leading to fin tube on drawings.
    c. Provide elements in lengths, sizes, and capacities as shown on drawings.

2. Fin Tube Element and Enclosure types:

    a. Type - B: Bare element installed behind casework. Use nominal 3-1/4" fins of tube size indicated.

        1) 3-1/4"x 3-1/4" aluminum fins, 50 per foot with bare single element nominal capacity of 1165 btu/ft-hr. at 65 deg. F entering air temperature and hot water at EWT 180 deg. F, LWT 160 deg. F.

    b. Type A: Wall mounted slope top enclosure nominally 4-1/4" deep x 18" with stamped slotted sloped front supply grille.

        1) 3-1/4"x 3-1/4" aluminum fins, 50 per foot with bare single element nominal capacity of 650 btu/ft-hr. at 65 deg. F entering air temperature and hot water at EWT 180 deg. F, LWT 160 deg. F.

        2) Color as selected by Architect.

3. Element Supports: Swinging, ball bearing, or sliding type designed to allow for expansion. Supports must allow free noiseless movement of pipe and elements.

4. Enclosures:

    a. Complete enclosures to run from wall-to-wall unless otherwise shown and noted on plans.

    b. Materials:

        1) General service: ASTM A-653/653M-94 G90 lock forming quality galvanized steel, prepared for painting via mill phosphatizing in accordance with ASTM A2092, unless otherwise noted.

        2) Kitchen service: 300 series stainless steel (304, 304L, 316, or equal) with No. 4 polish.

    c. Material gauges:

        1) 16 ga.: General service.
        2) 14 ga.: Cafeteria, Gymnasium, Corridor, and Storage and Mechanical Room service.
        3) 12 ga.: Aluminum enclosure required service.

d. Provide continuous enclosure back plate and back hanger channel of 20 ga. roll formed material same as cover, configured for positive support of cover and element. Include continuous urethane foam dirt seal between wall and channel.

e. Gusset braced cover construction with stamped outlet and inlet of configuration described above. Provide cover support brackets spaced as recommended by manufacturer but on center distances not greater than 4'. Provide brackets within 6" of end of cover and within 6" (on both sides) of each joint between sections or corner joints. All fasteners shall be concealed or tamper resistant. Fasteners shall match enclosure materials.

f. Provide matching die formed end caps, inside and outside corner pieces, wall sleeves, internal end plates, column enclosures, butt strips, valve compartments, riser chases, access doors and other accessories as shown on drawings and as required to fabricate neat, complete installation.

g. Enclosures and all trim accessories shall be phosphatized and painted inside and out with one coat of baked on alkyd enamel primer, then finished with baked enamel in color selected by Architect.

5. Valve Access Panel:

a. 12" wide minimum, full enclosure height access door with tamper resistant closure. Provide for reasonable service access where any of the following must be within enclosure (typical):

1) Isolation valve.
2) Air vent or drain.
3) Shut off valves, unions, P/T plugs, etc.
4) Temperature control valve.

b. Alternatively, provide nominally 24” wide section of enclosure at location of piping specialties, with tamper resistant fasteners designed and installed to facilitate ease of repeated maintenance.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas to receive equipment 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 installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.
D. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 INSTALLATION

A. Install equipment in compliance with NFPA 90A.
B. Install equipment level and plumb.
C. Suspend motorized equipment from structure with threaded steel rods. Vibration isolators are specified in Section 23 05 43 “Mechanical Vibration and Movement Control.
D. Refer to Section 23 63 00 "Refrigerant Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

## 3.3 FREEZE-PROTECTION

A. Take all precautions to prevent uncontrolled infiltration of outdoor air to coils and piping, including (but not necessarily limited to) following preventative steps:

B. Provide sleeves, safing, insulation, caulking, etc..., as required to make neat and airtight connection to outside air intakes, with no uncontrolled infiltration permitted.

C. If walls are in such condition that it is impossible to plumb the units with the walls and get correct sealing through standard methods, notify the Owner and Architect of proposed solution, and modify methods as required. Units must seal tightly against the walls and prevent infiltration.

D. Insure that adapter back wall boxes are properly installed and sealed and that no air is permitted to leak past them. Insulate per Section 23 07 00 – HVAC Insulation.

E. Adjust outdoor air dampers on the units to close tightly when in the unoccupied position (100% closed).

F. All openings in the outside air intake path between the intake louver and the outside air control damper which could permit the uncontrolled entrance of outdoor air shall be sealed and insulated. This includes but is not limited to unused holes (knockouts, etc.,), spaces around pipes and conduits, sealing wall sleeve to wall, sealing around intake louver, and other openings into piping and air compartments.

G. Insure that all freeze protection controls are in place and functional prior to freezing weather. During initial freezing weather, man job and continuously inspect for freeze concerns, provide report to Architect and Owner immediately and correct any discovered conditions which may result in freeze damage.

## 3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Unless otherwise indicated, install shutoff valve and union or flange at each connection.

3. Connect piping to equipment using specialties as detailed on drawings, with at minimum isolation valves, unions, and P/T test ports supply and return, with control valve on return as specified.

4. Pipe cooling coil condensate through properly sized accessible p-trap to approved point of indirect waste discharge. Pipe auxiliary drain pan connection to point of conspicuous discharge where minimal damage to building components will occur. Coordinate location of discharge with Owner and Architect in field.

B. Install refrigerant piping as required by Division 23 Section "Refrigerant Piping," and add refrigerant as required to compensate for length of piping.

C. Connect supply and return ducts to ducted equipment with flexible duct connectors specified in Section 23 31 00 " Ductwork". Comply with safety requirements in UL 1995 for duct connections.

D. Ground and wire equipment according to the stricter of manufacturer's and Division 26 requirements.

## 3.5 FIELD QUALITY CONTROL

A. Ensure Manufacturers provide:

1. Thorough instruction of installing Contractor's personnel in installation of units.
2. Instruction for Owner's personnel in operation and care of equipment.
3. Maintenance brochure.
4. Adjustment of air discharge pattern to suit each room as directed and approved.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. 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. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

D. After installing equipment, inspect for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

E. Remove and replace malfunctioning and damaged units and retest as specified above.

## 3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 82 00

# SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section and to all of Divisions 26.

### 1.2 SUMMARY

A. Section Includes:

1. General requirements applicable to components and systems included in Electric Contract.

B. Products Installed but Not Furnished Under This Section

1. Make electrical connections to equipment shown on Drawings and furnished by other Contractors. Obtain approved wiring diagrams and location drawings for roughing in and final connections from Contractor furnishing equipment.

### 1.3 REFERENCES

| | | |
|---|---|---|
| A. | AIA | American Institute of Architects |
| B. | ADA | Americans with Disabilities Act |
| C. | AISC | American Institute of Steel Construction |
| D. | ANSI | American National Standards Institute |
| E. | ASTM | ASTM International |
| F. | IBC | International Building Code |
| G. | IEEE | Institute of Electrical and Electronics Engineers, Inc. (The) |
| H. | IES | Illuminating Engineering Society of North America |
| I. | NEC | National Electrical Code |
| J. | NEMA | National Electrical Manufacturers' Association |
| K. | NETA | International Electrical Testing Association |
| L. | NFPA | National Fire Protection Association |
| M. | UL | Underwriters' Laboratories, Inc. |

### 1.4 SYSTEM DESCRIPTIONS

A. Inspection of Existing Systems: Inspect each existing system scheduled for modification in presence of Authorized Owner's Representative and issue a deficiency report to Owner and Architect listing conditions found prior to any removals, relocations, or additions. Modified systems include (but are not limited to):

1. Power distribution.
2. Power generation system.
3. Lighting.
4. Theatrical Lighting system.
5. Emergency lighting.

B. Design Requirements - Provide complete systems, properly tested, balanced, and ready for operation including necessary details, items and accessories although not expressly shown or specified, including (but not limited to):

1. Wiring and raceway for work specified in Project Manual and shown on Drawings.

2. Electrical devices and equipment for work specified in Project Manual and shown on Drawings.

3. Systems included, but not limited to:

a. Electrical distribution.
b. Electrical connections.
c. Power generation system.
d. Lighting.
e. Theatrical Lighting system.
f. Emergency lighting.

C. Electric Layouts: Arrange panels; disconnect switches, enclosed breakers, equipment, raceways, and similar components neatly, orderly and symmetrically. Provide 3/4-inch fire treated, gray painted plywood backboards for surface mounted panels, disconnect switches, enclosed breakers, and similar equipment. Arrangements shown on Drawings are diagrammatic only; provide and adjust raceways, wiring, and other components as required.

D. Power Interruptions and Scheduled Outages: Coordinate scheduling of all power interruptions and outages with Owner. Confirm with Owner prior to interruption of power, which building systems are considered critical and must remain operational during the interruption. If a scheduled power outage is to extend beyond one standard workday, provide temporary power to operate critical building systems (including, but not limited to fire alarm system, security system, building access control system, and building energy management control system).

## 1.5 SUBMITTALS

A. General Division 26 submittal requirements:

1. Comply with requirements of SECTION 01 33 00 – SUBMITTAL PROCEDURES and as modified below.

2. Product Data: Submit product data for items listed in individual technical section. Clearly identify manufacturer, pertinent design, function, materials, construction and performance data specifically addressing specification description and Contract Document requirements of item. Strike out products that are not applicable to item being submitted, where more than one product is indicated on manufacturer product literature.

a. Cover Sheet: Attach cover sheet, identified in Section 01 33 00, to Product Data of each item submitted. Provide cover sheet for only one type of item with related accessories, equipment with related components. Do not combine unrelated items under the same cover sheet.

b. Specified Equivalent Product Data: Submit manufacturer's product information including product literature, technical specifications and descriptions, performance data and, and similar items to demonstrate compatibility with Basis-of-Design Equipment as specified in the "Part 2 – Products" of each technical section.

3. Shop Drawings: Submit detailed drawings for electrical equipment layouts, showing exact sizes and locations for approval before beginning work.

a. Do not proceed with installation of systems in each area until agreement is reached with all concerned on exact arrangements for each room or area, unless otherwise directed by Architect. If Contractor proceeds prior to resolving conflicts, Contractor shall modify installed Work as required to permit other systems to proceed with a coordinated installation.

b. Specified Equivalent Drawings: Submit detailed drawings of proposed Specified Equivalents, indicating proposed installation of equipment and showing maintenance clearances, required service removal space other pertinent revisions to arrangement and configuration shown in Contract Documents.

4. Samples: On all submittals, indicate standard factory color and factory finish surfaces. Where more than one color is available, selection will be made by Architect from manufacturer's full range of colors. Electronically transmitted color samples are not acceptable.

## 1.6 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for penetration firestopping materials. Include ratings, furnished specialties and accessories.

1. Penetration firestopping materials.
2. Penetration firestopping assembly drawings.

## 1.7 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Codes and Standards: Comply with applicable Federal, State and local building and electrical codes, laws, ordinances, and regulations, and comply with applicable NFPA, National Electrical Code and utility company requirements and regulations. Provide Underwriters Laboratories Seal on all materials.

2. Permits and Inspections: Obtain approvals, tests, and inspections required by Architect, Engineer, local electrical inspector, agent or agency specified in Project Manual, or National, State, or local codes and ordinances.

    a. Schedule electrical inspection by an agency acceptable to the local authority having jurisdiction and submit final inspection certificate to Architect.
    b. Furnish materials and labor necessary for tests and pay costs associated with tests and inspections.
    c. Conduct tests under load for load balancing and where required by codes, regulations, ordinances, or technical Specification.

3. 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.

## 1.8 DELIVERY, STORAGE AND HANDLING

A. Storage and Protection:

1. Take precautions to store materials and products to protect finishes and not permit dust and dirt to penetrate equipment.
2. Replace equipment damaged beyond reasonable repair as required by Architect.
3. Refinish any equipment with marks, stains, scratches, dents, and other aesthetic damage that doesn't impede operation of equipment as required by Architect.

## 1.9 COORDINATION OF WORK

A. New Construction:

1. Openings, Chases, Recesses, Sleeves, Lintels and Bucks (required for admission of Electric Contract systems and components): Coordinate requirements with General Contractor for inclusion in General Contract. Furnish necessary information (e.g. locations and sizes) to General Contractor in ample time for installation of systems and components included in Electric Contract.

2. Anchor Bolts: Deliver to Contractor responsible for General Work anchor bolts required for Electric Contract construction that are to be installed in construction included in General Contract.

3. Locate settings, check locations as installation in General Contract progresses, and provide templates or holding fixtures as required to maintain proper accuracy.

B. Existing Construction:

1. Unless otherwise specified, employ Contractor responsible for General Work for all cutting, patching, repairing, and replacing of general work required for installation of systems and components included in Electric Work. Secure approval from Architect's representative before cutting.

2. Anchor Bolts: Deliver to Contractor responsible for General Work anchor bolts required for Electric Work construction that are to be installed in construction included in General Contract. Provide templates or holding fixtures as required to maintain proper accuracy.

3. Access Doors: Provide access doors shown on Drawings, or as required for access to pull boxes, junction boxes, relays and other electrical devices requiring periodic inspection, adjustment or maintenance, where located above or within inaccessible walls or ceilings, and including cutting and patching of adjacent walls and ceilings to match existing materials and finishes.

## 1.10 ALTERATION PROCEDURES

A. In locations where existing devices are indicated to be disconnected and removed and existing power circuit or communications cable is not scheduled to be reused:

1. Remove circuit conductors back to source.

2. Modify panel directory for that circuit.

3. Remove all existing exposed and unexposed accessible raceway.

4. Provide blank cover plates or wall infill (as indicated on plans) and as described below:

a. For single gang and multi-gang switch boxes in public or occupied spaces; stainless steel coverplates.

b. For single gang and multi-gang boxes in un-occupied spaces; stainless steel, galvanized steel or PVC coverplates.

c. For boxes larger than standard switch boxes in public or occupied spaces; remove existing box and provide wall infill, matching existing sub-surface and finished surface conditions. Paint wall to match surrounding finishes.

d. For boxes larger than standard switch boxes in un-occupied spaces; 18 gage galvanized sheet metal coverplate with machined edges. Prime and paint to match surrounding finish conditions.

5. Patch and paint existing walls where disturbed by the electrical work.

B. In locations where existing devices are to remain in place, ensure circuits feeding such devices remain operational. Modify existing circuits as required to allow new construction to occur and to maintain necessary circuitry to existing devices for complete and proper operation.

C. In locations where entire existing system is being removed or modified:

1. Refer to individual system specification sections for documentation and inspection requirements prior to any alteration work on any system.
2. Take all necessary measures to ensure that down time will not compromise safety.
3. Notify Owner, Architect and other Contractors not less than 2 weeks prior to interruptions in service.

4. Coordinate work schedule to minimize duration of system outage during hours when building is occupied.

## PART 2 - PRODUCTS

### 2.1 PENETRATION FIRESTOPPING

A. Comply with requirements for sealants in fire rated penetrations specified in Section 07 84 13 “Penetration Firestopping”.

B. Submit Manufacturers Product Data Sheets for each type of product selected. Certify that Firestop Material is free of asbestos and lead paint and complies with local regulations.

1. Certification by firestopping manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs) and are nontoxic to building occupants.

C. Submit system design listings, including illustrations from qualified testing and inspection agency that is applicable to each firestop configuration.

### 2.2 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink, non-metallic, high strength grout, suitable for interior and exterior, above and below grade applications.

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

### 2.3 SEALANTS

A. Comply with requirements for sealants in non-fire rated penetrations specified in Section 07 92 00 "Joint Sealants."

B. Mildew-Resistant, Single-Component, Acid-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.

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. BASF Building Systems; Omniplus.
b. Dow Corning Corporation; 786 Mildew Resistant.
c. GE Advanced Materials - Silicones; Sanitary SCS1700.

## 2.4 ACCESS DOORS

A. Comply with requirements for access doors specified in Section 08 31 13 “Access Doors and Frames” for product requirements.

## 2.5 PAINT AND FINISHES

A. Refer to Division 09 for painting and finishing.

# PART 3 - EXECUTION

## 3.1 CUTTING AND PATCHING

A. Do not cut and vapor barriers or waterproofing for admission of any equipment or materials and do not pierce any structural members without written permission from Architect.

B. Furnish and install sleeves, inserts, panels, raceways, boxes, and similar infrastructure., ahead of general construction work and maintain Contractor personnel at Site during installation of general construction work to be responsible for and to maintain these items in position.

C. Unless otherwise noted elsewhere in Contract Documents, bear expense of cutting, patching, repairing or replacing of work of other trades made necessary by any fault, error or tardiness on part of Electrical Contract or damage done by Electric Contract. Employ and pay Contractor whose work is involved.

## 3.2 DEMONSTRATION OF COMPLETE ELECTRICAL SYSTEMS

A. Thoroughly demonstrate and instruct Owner's designated representative in care and operation of electrical systems and equipment furnished and installed in Electric Contract.

1. System Operator: Maintain competent operator at building for at least 2 days in 2 consecutive weeks after Owner takes occupancy of major parts of building to operate systems and equipment in presence of Owner's representative.

2. Factory Representative: In addition to demonstration and instruction specified above, provide technically qualified factory representatives from manufacturers of major equipment, to train Owner's representatives in care and operation of applicable products as specified in applicable technical sections of Division 26.

3. Coordinate and schedule time and place of all training through the Architect at the Owner’s convenience.

4. Submit letters attesting to satisfactory completion of instructions, including date of completion of instruction, names of persons in attendance, and signature of Owner’s authorized representative.

5. Architect's representative must be present when Owner's representatives participate in instruction

6. The following equipment and systems are included:

    a. Emergency generator.
    b. Theatrical Lighting system.

## 3.3 GROUTING

A. Mix and install grout for electrical equipment base bearing surfaces, 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.

## 3.4 SEALANTS

A. Install sealants according to the requirements specified in Section 07 92 00 "Joint Sealants."

## 3.5 FIRESTOPPING

A. Install firestopping according to the requirements specified in Section 07 84 13 "Penetration Firestopping."

B. Applied Fireproofing:

1. Coordinate the installation of hangers, supports and accessories from the structural steel with the fireproofing installation. Install all hangers and supports prior to installation of fireproofing.

2. Repair or replace existing fireproofing removed as a part of Electrical Work installation.

    a. Employ the services of an approved fireproofing contractor to repair or replace the fireproofing by patching any areas that have been removed or damaged due to the installation of work after the completion of the fireproofing.

C. Repaired or replacement fireproofing shall match the fireproofing adjacent to the repaired area. All warranties shall be maintained.

## 3.6 ACCESS DOORS

A. Install access doors according to the requirements specified in Section 08 31 13 "Access Doors and Frames."

END OF SECTION 26 05 00

# SECTION 26 05 01 – HAZARDOUS MATERIAL DISPOSAL

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section and to all of Divisions 26.

### 1.2 SUMMARY

A. Section Includes:

1. Selective removal and subsequent off-site disposal of the following hazardous waste:

   a. PCB containing light ballasts.
   b. Mercury containing fluorescent light tubes.

2. Requirements for transport and disposal of hazardous waste materials by legal and appropriate means.

B. Related Sections

1. Supplementary Conditions: Additional insurance requirements for hazardous waste disposal.

### 1.3 REFERENCES

A. Regulatory Requirements

1. United States Environmental Protection Agency (EPA)

   a. 40 CFR 260 - Hazardous waste management system: General
   b. 40 CFR 261 - Identification and Listing of Hazardous Waste.
   c. 40 CFR 262 - Standards Applicable to Generators of Hazardous Waste.
   d. 40 CFR 263 - Standards Applicable to Transporters of Hazardous Waste
   e. 40 CFR 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
   f. 40 CFR 265 - Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
   g. 40 CFR 266 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
   h. 40 CFR 268 - Land Disposal Restrictions
   i. 40 CFR 270 - EPA Administered Permit Programs: The Hazardous Waste Permit Program
   j. 40 CFR 761 - Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution In Commerce, and Use Prohibitions.

2. United States Department of Transportation (DOT)

   a. 49 CFR 171 - General Information, Regulations, and Definitions.
   b. 49 CFR 172 - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements.
   c. 49 CFR 173 - Shippers - General Requirements for Shipments and Packaging.
   d. 49 CFR 174 - Carriage by Rail.
   e. 49 CFR 175 - Carriage by Aircraft.
   f. 49 CFR 176 - Carriage by Vessel.
   g. 49 CFR 177 - Carriage by Public Highway.
   h. 49 CFR 178 - Specifications for Packaging.
   i. 49 CFR 179 - Specifications for Tank Cars.
   j. 49 CFR 180 - Continuing Qualification for Maintenance of Packaging.

3. New York State Department of Environmental Conservation (DEC)

   a. 6 NYCRR 360 - Solid Waste Management Facilities
   b. 6 NYCRR 364 - Waste Transporter Permits
   c. 6 NYCRR 370 - Hazardous Waste Management System: General.
   d. 6 NYCRR 371 - Identification and Listing of Hazardous Wastes.
   e. 6 NYCRR 372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities.
   f. 6 NYCRR 373-1 - Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements.
   g. 6 NYCRR 373-2 - Final Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities.
   h. 6 NYCRR 373-3 - Interim Status Standards for Owners and Operators of Hazardous Waster Facilities.
   i. 6 NYCRR 376 - Land Disposal Restrictions.

## 1.4 DEFINITIONS

A. Remove: Remove and legally dispose of items except those indicated to be reinstalled, salvaged, or to remain Owner's property.

## 1.5 PROJECT SITE

A. Existing Conditions

1. Building Occupancy: Owner will occupy portions of building immediately adjacent to areas of hazardous material removal operations. Conduct removal operations in manner that will minimize need for disruption of Owner's normal operations. Provide minimum of 72 hours advance notice to Owner of removal activities that will affect Owner's normal operations.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT

A. Labeling and Packaging Materials: Provide labeling and packaging materials as required by 49 CFR 173 Shippers - General Requirements for Shipments and Packaging.

B. Hazardous Waste Disposal Vehicles: Provide vehicles for transporting hazardous waste possessing valid Industrial Waste Hauler Permit and equipped with appropriate placards affixed as prescribed by United States Department of Transportation regulations.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which hazardous material disposal is to be conducted and notify affected Contractors and Architect in writing of any conditions detrimental to proper and timely hazardous material disposal. Do not proceed with disposal until unsatisfactory conditions have been corrected.

### 3.2 REMOVAL, PACKAGING, TRANSPORTATION AND DISPOSAL PROCEDURES

A. Removal: Remove light ballasts and fluorescent light tubes whole and intact. Do not release PCBs or mercury to the environment.

B. Packaging: Package, label, and mark all hazardous waste materials in accordance with applicable requirements of 49 CFR 173, 178 and 179.

C. Temporary On-Site Storage and Protection: Provide storage on site of hazardous materials removed from service and scheduled for disposal to prevent damage or vandalism.

D. Temporary On-Site Storage and Protection: Provide storage on site of hazardous materials removed from service and scheduled for disposal complying with requirements of 6 NYCRR 372.2 (a) (8). Do not exceed 180 days storage on site.

E. Disposal - Transport hazardous waste to treatment or disposal facility that:

1. Is permitted, licensed or registered by state to dispose of hazardous waste;

2. Has interim status to dispose of hazardous waste;

3. Is authorized to manage hazardous waste under Resource Conservation and Recovery Act (RCRA) or

4. Is facility which:

a. Beneficially uses or reuses, or legitimately recycles or reclaims its waste; or

b. Treats its waste prior to beneficial use or reuse, or legitimate recycling or reclamation.

## 3.3 ADJUSTING/CLEANING

A. At least weekly, remove from building site debris, rubbish, and other materials resulting from hazardous material disposal operations.

1. If additional hazardous materials are encountered during hazardous material disposal operations, comply with applicable regulations, laws, and ordinances concerning removal, handling, and protection against exposure or environmental pollution.

2. Burning of removed materials not permitted on Project Site.

3. Transport materials removed and legally dispose off-site.

END OF SECTION 26 05 01

# SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 2000 V and less.
2. Wires and cables for PV systems rated 2000 V and less.
3. Connectors, splices, and terminations rated 2000 V and less.

B. Related Requirements:

1. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

### 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS AND CABLES

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. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

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. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable used in VFC circuits.

E. Conductors: Copper complying with NEMA WC 70/ICEA S-95-658.

1. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/ THWN-2 and Type XHHW-2.

F. Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

## 2.2 CONNECTORS AND SPLICES

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. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.
6. Ideal Industries/Buchanan

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. Conductors No. 8 AWG and smaller: Screw on, wing nut wire connectors with fixed square wire threads and wide throated skirt. UL 486C Listed.

2. Conductors No. 6 AWG to 3/0 AWG: Bolt on type or crimped type compression, seamless copper connectors using hand or hydraulic tool, color coded to wire size. Connector shall be electro-tin plated to resist electrolytic corrosion. UL 486A and UL 486B Listed.

3. Conductors No. 4/0 AWG and larger: Compression type solderless connector, long barrel seamless copper with minimum 2 pressure points per conductor. Fully compatible with industry standard crimping tool-die sets. Color coded to wire size and electro-tin plated to resist electrolytic corrosion. UL 486A Listed.

# PART 3 - EXECUTION

## 3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; stranded.
B. Branch Circuits: Copper, stranded.

## 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.
B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.
D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway**.**
E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.
F. Feeders in Cable Tray: Metal-clad cable, Type MC.
G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway
H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway
J. Branch Circuits Installed below Raised Flooring: Metal-clad cable, Type MC.
K. Branch Circuits in Cable Tray: Metal-clad cable, Type MC.
L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

## 3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Wire and Cable Installation: Install all wire and cable in approved raceway with exit light circuits, emergency lighting circuits, and special systems wiring installed in separate raceways. Use UL approved lubricants for wire pulling. Tag all feeders, subfeeders, special system wiring and branch circuit wiring at each pull box, junction box, and gutter space indicating point of origin and termination. Install green grounding wire in all raceways for connection to equipment, motors, transformers, and similar equipment. Install low voltage cables as detailed in individual sections.

B. Splices and Terminations: Make all splices accessible. Insulate all splices, taps, and connections to insulation value of conductor. Follow all instructions and recommendations of splice material manufacturer. Terminate low voltage cables with termination blocks as described in individual sections.

1. Common Neutral Conductor: Do not use common neutral for multiple branch circuits.

C. Pull all conductors together where more than one is being installed in raceway.

D. Do not exceed maximum pulling tension of wire being installed. Use pulling compound or lubricant, where necessary. Use compound that will not deteriorate conductor or insulation.

E. Use pulling means, including fish tape, cable or rope that cannot damage raceway or wire.

F. Replace wiring damaged during installation.

G. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

H. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

I. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

J. 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.

K. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

L. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

M. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

N. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

O. Metal Clad Type "MC" Cable:

1. Install MC cable, parallel and perpendicular to surfaces or structural members following surface contours, where possible.

2. Do not use MC cable for home runs (from panel to first device in branch circuit).

3. Do not install exposed metal clad cable in any areas, including mechanical and electrical spaces.

4. Do not penetrate floor slabs with MC cable.

5. Metal clad cable may be used for switch, receptacle, light fixture, device and fixture branch circuit wiring above ceilings and in walls beyond corridor walls.

6. MC cable shall include a neutral, whether used or not, to a light switch location.

7. Above corridor ceilings, use MC cable for 6 foot light fixture whips.

8. Maintain a clearance of at least 6 inches from hot water and other high temperature pipes and telecommunications conduits, and at least 12 inches from unshielded telecommunications cables.

9. Support MC cable every 6 feet, and within 1 foot of every box, fitting, and cable termination. Do not support MC cable on hung ceilings or on ceiling support wires. The use of cable ties to support MC cable is prohibited.

10. Use MC cable in branch circuit wiring in movable metal partitions and movable gypsum partitions. Install conductors in accordance with partition manufacturer's recommendations.

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-486B.

B. Make splices, terminations, 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 6 inches of slack.

D. Splices:

1. Dry Locations:

a. Conductors No. 8 AWG or Smaller: Use spring type pressure connectors or indent type pressure connectors with insulating jackets (except where special type splices are required).

b. Conductors No. 6 AWG or Larger: Use un-insulated indent type pressure connectors. Fill indentations with electrical filler tape and apply insulation tape to insulation equivalent of the conductor, or insulate with heat shrinkable splices.

c. Gutter Taps in Panelboards: Install gutter tap, fill indentations with electrical filler tape and apply insulation tape to insulation equivalent of the conductor, or insulate with gutter tap cover.

2. Damp Locations: As specified for dry locations, except apply moisture sealing tape over entire insulated connection (moisture sealing tape not required if heat shrinkable splices are used).

3. Wet Locations: Use un-insulated indent type pressure connectors and insulate with resin splice kits or heat shrinkable splices. Exception: Totally enclosed splices above ground protected in NEMA 3R, 4, 4x enclosures may be spliced as specified for damp locations.

E. Terminations:

1. Conductors No. 10 AWG or Smaller - Use terminals for:

a. Connecting control and signal wiring to terminal strips.
b. Connecting wiring to equipment designed for use with terminals.

2. Conductors No. 8 AWG or Larger - Use compression or mechanical type lugs for:

a. Connecting cables to flat bus bars.
b. Connecting cables to equipment designed for use with lugs.

3. For Conductor Sizes Larger than Terminal Capacity on Equipment: Reduce larger conductor to maximum conductor size that terminal can accommodate (reduced section not longer than one foot). Use compression or mechanical type connectors suitable for reducing connection.

F. Provide insulated green ground conductor for each branch and feeder circuit.

G. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

H. All connections and terminations installed according to manufacturer's recommendations.

I. All bolted or screw-type terminations specifically torqued to setting specified by manufacturer.

## 3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

## 3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.7 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 078413 "Penetration Firestopping."

## 3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.

b. Test bolted connections for high resistance using the following:

1) A low-resistance ohmmeter.
2) Calibrated torque wrench.
3) Thermographic survey after electrical system activation and is under load.

c. Inspect compression applied connectors for correct cable match and indentation.

d. Inspect for correct identification.

e. Inspect cable jacket and condition.

f. Insulation-resistance test on each conductor with respect to ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

g. Continuity test on each conductor and cable.

h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice and termination in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

b. Record of Infrared Scanning: Prepare a certified report that identifies splices and terminations checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice and termination 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 05 19

# SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes: Grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Foundation steel grounding.

### 1.3 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. Comply with UL 467 for grounding and bonding materials and equipment.

### 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

### 1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings and grounding connections for separately derived systems based on NETA MTS.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

2) Include recommended testing intervals.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

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. Comply with UL 467 for grounding and bonding materials and equipment.

### 2.2 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 B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: No. 6, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) 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 (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 inch thick by 2 inches wide by 8 inches long (6.3 by 50 mm by 200 mm), with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. fiberglass reinforced polyester, impulse tested at 5000 V.

### 2.3 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 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, non-reversible compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Non-reversible compression or exothermic-type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Non-reversible compression or exothermic-type, copper or copper alloy.

J. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

K. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

## 2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad, sectional type; 10 feet by 3/4 inch (3 m by 19 mm) in diameter.

# PART 3 - EXECUTION

## 3.1 APPLICATIONS

A. Conductors: Install stranded conductors for all sizes unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum unless indicated otherwise on drawings.

1. Bury at least 24 inches below grade.

C. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

D. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

E. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) 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; connect to horizontal bus.

F. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: 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 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 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink 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 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. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

## 3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.

2. Lighting circuits.

3. Receptacle circuits.

4. Single-phase motor and appliance branch circuits.

5. Three-phase motor and appliance branch circuits.

6. Flexible raceway runs.

7. Armored and metal-clad cable runs.

8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

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.

C. 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.

D. Water Heater, Heat-Tracing, and Antifrost 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.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. 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.

F. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a 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 (6.3-by-100-by-300-mm) grounding bus.

3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. 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.

H. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare**,** tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

## 3.4 INSTALLATION

A. 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.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) 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 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 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. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

## 3.5 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding terminal bar 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. 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 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 test well, 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.

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

C. Prepare and submit all test and inspection reports.

D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity to 1000 kVA: 5 ohms.
2. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
4. Substations and Pad-Mounted Equipment: 5 ohms.
5. Manhole Grounds: 10 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

# SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

### 1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.
B. RMC: Rigid metal conduit.

### 1.4 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 times the applied force.

### 1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

### 1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with Division 3 section ‘Cast-in-Place Concrete’.

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. 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. 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.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. U-Channel Strut Systems: Provide 16 gauge steel U-channel strut system for supporting electrical equipment of types and sizes indicated with 9/16-inch diameter holes at 8 inches on center on top surface, with standard galvanized or PVC finish and following fittings that mate and match with U-channel:

a. Fixture hangers.
b. Channel hangers
c. End caps
d. Beam clamps
e. Wiring stud.
f. Thin-wall raceway clamps.
g. Rigid conduit clamps.
h. Raceway hangers.
i. U-bolts.

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 A 36/A 36M, 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. 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) 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. 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) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) 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 A 325.

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.

## 2.3 MANUFACTURED SUPPORTING DEVICES

A. General: Provide supporting devices, complying with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation, and as specified in this Section. Where more than one type of device meets indicated requirements, select device according to Contractor's option.

1. Fasteners:

a. Standard Bolts and Nuts: ASTM A 307, Grade A, regular hexagon head.
b. Lag Bolts: FS FF-B-561, square head type.
c. Machine Screws: FS FF-S-92, cadmium plated steel.
d. Machine Bolts: FS FF-B-584 heads; FF-N-836 nuts.
e. Wood Screws: FS FF-S-111 flat head carbon steel.
f. Plain Washers: FS FF-W-92, round, general assembly grade carbon steel.
g. Lock Washers: FS FF-W-84, helical spring type carbon steel.
h. Toggle Bolts: Tumble-wing type; FS FF-B-588, type, class and style as required to sustain load.
i. Stainless Steel Fasteners: Type 302 for interior Work; Type 316 for exterior Work.

# 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 RMC as required by 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.

E. Install hangers, supports, clamps and attachments to support raceway properly from building structure. Arrange for grouping of parallel runs of horizontal raceways to be supported together on trapeze type hangers where possible.

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 RMC 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. Fasteners

1. Materials:

a. Dry Locations: Use cadmium or zinc coated anchors and fasteners.
b. Damp and Wet Locations: Use hot dipped galvanized or stainless steel anchors and fasteners.
c. Corrosive Atmospheres Or Other Extreme Environmental Conditions: Use fasteners made of materials suitable for conditions.

2. Types (unless otherwise specified or indicated):

a. Use cast-in-place concrete inserts in fresh concrete construction for direct pull-out loads such as shelf angles or fabricated metal items and supports attached to concrete slab ceilings.

b. Use anchoring devices to fasten items to solid masonry and concrete when anchor is not subjected to pull out loads, or vibration in shear loads.

c. Use toggle bolts to fasten items to hollow masonry and stud partitions.

E. Attachment Devices

1. Make attachments to structural steel or steel bar joists wherever possible. Provide intermediate structural steel members where required by support spacing.

2. Make attachments to steel bar joists at panel points of joists.

3. Do not drill holes in main structural steel members.

4. Use "C" beam clamps for attachment to steel beams

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Light Steel: Sheet metal screws.

7. 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

8. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

F. Raceway Support

1. Use pipe straps and specified method of attachment where raceway is installed proximate to surface of masonry construction.

2. Use hangers secured to surface with specified method of attachment where raceway is suspended from the surface.

3. Use "C" beam clamps and hangers where raceway is supported from steel beams.

4. Use channel support system supported from structural steel for multiple parallel raceway runs.

5. Where raceways are installed above ceiling, do not rest raceway directly on runner bars, T-bars, etc.

   a. Raceway Sizes 2-1/2 Inches and Smaller: Support raceway from ceiling supports or from construction above ceiling.
   b. Raceway Sizes Over 2-1/2 Inches: Support raceway from beams, joists, or trusses above ceiling.

G. Light Fixture Support

1. Do not support fixtures from ceilings or ceiling supports unless specified or indicated on Drawings.

   a. Comply with NEC, Article 410.36 – Means of Support.
   b. Support fixtures with hanger rods attached to beams, joists, or trusses–of largest standard diameter-that fits in mounting holes of fixture.
   c. Where approved, channel supports may span and rest upon lower chord of trusses and be used to support lighting fixtures.
   d. Where approved, channel supports may span and be attached to underside of beams, joists, or trusses and be used to support lighting fixtures.

2. Use 2 nuts and 2 washers on lower end of each hanger rod to hold and adjust fixture (one nut and washer above top of fixture housing, one nut and washer below top of fixture housing).

   a. Where adequately supported outlet box is specified to support fixture or be used as one point of support, support box so that box may be adjusted to bring face of outlet box even with surface of ceiling.

3. Ceiling Mounted Lighting Fixtures: Provide at least following number of supports with additional supports when recommended by fixture manufacturer or shown on Drawings.

   a. Support individual fluorescent fixtures less than 2 feet long at 2 points.

   b. Support continuous row fluorescent fixtures less than 2 feet wide at points equal to number of fixtures plus one. Uniformly distribute points of support over row of fixtures.

   c. Support individual fluorescent fixtures 2 feet or wider at 4 corners.

   d. Support continuous row fluorescent fixtures 2 feet or wider at points equal to twice number of fixtures plus 2. Uniformly distribute points of support over row of fixtures.

   e. Use adequately supported outlet box as one point of support for fixtures weighing less than 50 pounds.

   f. Support recessed mounted fixtures directly from suspension system of suspended acoustical ceilings and securely fasten fixtures to framing members of ceiling using lock clips, wirelashing or leveling supports. Support each fixture weighing more than 50 pounds (including lamps) independent of suspended ceiling grid.

4. Wall Mounted Lighting Fixtures: Provide at least following number of supports with additional supports when recommended by fixture manufacturer or shown on Drawings.

   a. Support individual fluorescent fixtures 2 feet long or less at 2 points.
   b. Support individual fluorescent fixtures over 2 feet long at 3 points.
   c. Support continuous row fluorescent fixtures at points equal to twice number of fixtures. Uniformly distribute points of support.
   d. Adequately supported outlet box may be used as one point of support for fixtures weighing less than 50 pounds

H. Channel Support System: Channel supports may be used, as approved, to accommodate mounting of equipment with following material and finish.

1. Dry Locations: 16-gage steel channel support system with standard finish.
2. Damp and Wet Locations: 16-gage steel channel support system with hot dipped galvanized or PVC finish

## 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 5 – Metal Fabrications 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/D1.1M.

## 3.4 CONCRETE BASES

A. Construct concrete bases of dimensions for approved equipment but not less 4 inches (100 mm) larger in both directions than the supported unit. Anchors will be a minimum of 10 bolt diameters from the edge of the base.

B. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 3 Cast-in –Place Concrete.

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.

## 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. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

# SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

### 1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.
B. ENT: Electrical nonmetallic tubing.
C. EPDM: Ethylene-propylene-diene terpolymer rubber.
D. FMC: Flexible metal conduit.
E. GRC: Galvanized rigid steel conduit
F. LFMC: Liquidtight flexible metal conduit.
G. LFNC: Liquidtight flexible nonmetallic conduit.
H. NBR: Acrylonitrile-butadiene rubber.
I. RNC: Rigid nonmetallic conduit.

### 1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets, custom enclosures, cabinets, handholes and boxes.

1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

### 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.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT, TUBING AND FITTINGS

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. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. O-Z Gedney; a unit of General Signal.
7. Wheatland Tube Company.

B. Galvanized Rigid Steel Conduit (GRC): Rigid, hot dipped galvanized steel with galvanized threaded malleable iron fittings and bushings with insulated throat (galvanized steel). ANSI C80.1 and UL 6.

C. Electrical Metallic Tubing (EMT): Metallic galvanized steel tube with galvanized steel compression or setscrew type fittings and bushings with insulated throat (galvanized steel). ANSI C80.3 and UL 797.

D. Flexible Metal Conduit (FMC): Flexible, interlocked aluminum metal strip with galvanized screw-in type steel fittings. UL 1.

E. Liquid Tight Flexible Metal Conduit (LFMC) : Liquid-tight flexible metal raceway with single, flexible, continuous, interlocked and double-wrapped steel core galvanized inside and outside, coated with liquid tight jacket of flexible polyvinyl chloride (PVC). UL 360.

F. Fittings:

1. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

2. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.

3. Fittings for EMT:

a. Material: Steel .
b. Type: Setscrew or compression.

4. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

G. Joint Compound for Rigid Steel Conduit: 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. 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. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. CertainTeed Corp.; Pipe & Plastics Group.
6. Condux International, Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. Thomas & Betts Corporation.
12. RACO; a Hubbell Company.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. RNC: NEMA TC 2, UL 651,Type EPC-40-PVC**,** with matching fittings by same manufacturer as the conduit.

D. ENT: Comply with NEMA TC 13 and UL 1653.

E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

F. LFNC: UL 1660.

G. Fittings for LFNC: UL 514B.

H. Solvents and Adhesives: As recommended by conduit manufacturer.

## 2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

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. 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 installation.

## 2.4 METAL WIREWAYS

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. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, UL 870 and NEMA 250, Type 1, 12, 3R, as 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 or as indicated with manufacturer's standard enamel finish.

## 2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

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. Hubbell, Inc.
b. Thomas & Betts Corporation.
c. Walker Systems, Inc.; Wiremold Company (The).
d. Wiremold Company (The); Electrical Sales Division.

C. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.

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. Butler Manufacturing Company; Walker Division.
b. Enduro Systems, Inc.; Composite Products Division.
c. Hubbell Incorporated; Wiring Device-Kellems Division.
d. Lamson & Sessions; Carlon Electrical Products.
e. Panduit Corp.
f. Walker Systems, Inc.; Wiremold Company (The).
g. Wiremold Company (The); Electrical Sales Division.

## 2.6 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. 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. 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. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

C. Outlet Boxes

1. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

2. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy**,** Type FD, with gasketed cover.

3. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

4. Materials

a. Recessed Applications and Exposed Applications in Unfinished Spaces: Galvanized, stamped steel.

b. Boxes in stud walls shall be 4” square, 2 1/8” deep boxes with raised covers for power circuits. Provide “Far-Side” box support to keep box alignment parallel with wall face.

c. Boxes in masonry walls shall be 3 ½” deep masonry boxes, single or multigang as required

d. Exposed Applications: In finished spaces requiring exposed applications, provide boxes to match surface raceway system. In situations where surface mount conduits are allowed, condulet style boxes shall be used. Where surface mount devices are provided as components of specific systems, provide surface mount box from same manufacturer to match device.

e. Concrete and Wall in Wet Locations: Heavy duty cast aluminum, thermoset protective silver grey finish, with threaded mounting posts.

f. Weatherproof Outlet Boxes: Corrosion-resistant cast metal weatherproof outlet wiring boxes of appropriate type, shape, size and depth, with threaded conduit ends and cast metal face plates with cover suitably configured for each application~~,~~ and including face plate gaskets and corrosion resistant fasteners. Do not compromise outlet weatherproof integrity when attachment plug is inserted.

g. Junction and Pull Boxes: Galvanized code gauge sheet steel boxes with screw-on covers, of appropriate type, shape and size suitable for box location and installation with welded seams and equipped with stainless steel nuts, bolts, screws and washers.

5. Size: As required for number and size of raceways and conductors. Depth to suit wall depth and device installed.

6. Covers: Design and style for each type, outlet, junction box, etc.; NEMA rated for each location.

D. 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.
2. Nonmetallic Enclosures: Plastic.

E. 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.

F. Metal Floor Boxes:

1. Material: sheet 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. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

## 2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering of system contained within.
6. Conduit Entrance Provisions: Conduit-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: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

C. Source Quality Control for Underground Enclosures

1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

2. Tests of materials shall be performed by an independent testing agency.

3. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

4. 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 RACEWAY APPLICATION

A. Raceway Installation: Securely support raceway from building construction, separately from outlet boxes and junction boxes. Secure to masonry surfaces with expansion anchors. Use galvanized hanger rods, inserts and hangers. Conceal all raceway runs except in mechanical rooms, storage room ceilings, and areas above suspended ceilings. Run exposed raceway neatly, parallel and level, to ceilings, walls and floors. Make necessary offsets and bends to comply with construction. Install expansion fittings at all building expansion joints. Support all raceways with clamps per National Electric Code

1. GRC Installation: Use GRC in concrete slabs, below concrete slabs, below grade, damp locations, exterior locations and in hazardous locations. Where exposed leaving concrete slabs, extend minimum 6 inches above and below slabs. Use GRC elbows when penetrating concrete slab from PVC raceway below or in slabs.

2. RNC: Use for underground applications, in slabs, and below slabs. Provide rigid raceway when extending through slabs. Install in accordance with requirements of Article 352 of NEC. Make solvent-cemented joints in accordance with recommendations of manufacturer.

3. EMT: Use EMT for non-hazardous, dry locations above grade. As a minimum, use EMT in corridor ceilings, for home runs and in all unoccupied exposed interior areas. Surface mounted EMT shall not be used in finished areas without written permission from the Architect or Owner.

4. FMC: Use flexible metal conduit for final connections to motors, step-down transformers, vibrating machines, etc. Terminate with clamp type connectors and anti-short bushing. Maximum length of three feet.

5. LFMC: Use a maximum of two feet of liquid tight flexible conduit for connection of motors and for other electrical equipment where subject to movement and vibration and also where subjected to one or more of the following conditions:

    a. Exterior location.
    b. Moist or humid atmosphere where condensate can be expected to accumulate.
    c. Corrosive atmosphere.
    d. Subjected to water spray.
    e. Subjected to dripping oil, grease or water

6. LFNC: Use a maximum of three feet of liquid tight flexible nonmetallic conduit for connection to video cameras and other electrical equipment with extreme bending requirements and also where subjected to one or more of the following conditions:

    a. Exterior location.
    b. Corrosive atmosphere.

7. All non-metallic or flexible conduit shall contain a separate grounding conductor in addition to the circuit conductors.

8. Complete raceway installation before starting conductor installation.

9. Do not secure branch circuit wiring to ceiling support wires. Provide independent support wires dedicated only to electrical raceways.

10. Use roughing-in dimensions of electrically operated units furnished by supplier. Set conduit and boxes for connection to units only after receiving dimensions and after checking location with other trades.

11. Provide nylon pull cord in empty raceways. Test empty raceways with ball mandrel. Clear any raceway that rejects ball mandrel. Restore raceway and surrounding surfaces to original condition.

12. Fasten raceway terminations in sheet metal enclosures by 2 locknuts and terminate with bushing. Install locknuts inside and outside of enclosure.

13. Do not cross pipe shafts or ventilating duct openings with raceways.

14. Keep raceways at least 6 inches from parallel runs of flues, hot water pipes or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.

B. Concealed Raceways

1. Paint raceway threads in metallic raceways installed underground, in floors below grade, or outside with corrosion-inhibiting compound before assembling couplings. Draw coupling and raceway sufficiently tight to ensure water tightness.

2. For floors-on-grade, install raceways under concrete slabs.

3. Install underground raceways minimum of 18 inches below finished grade.

4. Provide raceway in furniture and any other cavity to effectively create a raceway system from the ceiling space to the outlet.

5. Stub-ups to Above Recessed Ceilings:

   a. Use EMT for raceways.
   b. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

C. Raceways in Concrete Slabs: Do not embed pipes other than electrical raceway in structural concrete and provide steel sleeves for raceway passing through concrete. Obtain Architect's approval for any variation from following requirements unless shown on Drawings. Request Architect's approval in writing accompanied by suitable sketch.

1. Place raceways between bottom reinforcing steel and top reinforcing steel.
2. Place raceways either parallel or at 90 degrees to main reinforcing steel.
3. Place nearly parallel raceways apart at least six times O.D. of raceway used.
4. Restrict O.D. of raceway in solid slabs to 1/4 of slab thickness with raceway placed in middle of that thickness.
5. Do not use raceway coating, except galvanizing or equivalent coating.
6. Do not cut or displace any reinforcement.

D. Install raceways to avoid damage or penetration of structural members. Avoid horizontal or cross runs in building partitions or sidewalls.

E. For raceway larger than 2 inches, provide minimum 2 inches between raceways vertically penetrating elevated concrete slabs. Provide fire-stopping and spray-on fireproofing at locations where raceways penetrate surface of floor slab that is part of fire rating required for construction.

F. Change from ENT to GRC before rising above floor. Arrange stub-ups so curved portions of bends are not visible above finished slab.

G. Exposed Raceways

1. Use exposed raceway on exterior surfaces and interior finished spaces only when raceway type and routing are approved by Architect and Owner's representative.

2. Install exposed raceway in unfinished spaces, crawl spaces, pipe spaces, or in areas with existing exposed raceway. In areas where walls/ceilings are to be painted, exposed raceways shall be painted to match.

3. Install exposed raceways and extensions from concealed raceway systems neatly, parallel with, or at right angles to walls of building.

4. Do not run raceway through walls with plaster finish or through masonry walls or floors. Install pipe sleeves for raceway runs through these areas.

5. Install exposed raceway to avoid interfering with ceiling inserts, lights or ventilation ducts or outlets.

6. Support exposed raceways using hangers, clamps or clips. Support raceways on each side of bends and space not more than 6 ft. O.C. for 1-inch raceway and not more than 8 ft. O.C. for 1-1/4-inch raceway.

7. Provide exposed raceways for outlets on waterproof walls and set anchors supporting raceway in waterproof cement.

8. Support multiple raceway runs on trapeze style assemblies. Do not support raceway or cable from pipe, ductwork, or other raceway systems.

9. Apply exposed raceways requirements specified above to raceways installed in space above hung ceilings and in crawl spaces.

10. Do not install raceway directly on floors.

H. Raceways for Optical Fiber Communications Cable

1. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
2. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: Plenum-type, optical fiber/communications cable raceway
3. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, in damp or wet locations.

I. Minimum Raceway Size: 1/2-inch (16-mm)

J. Surface Raceways: Use surface raceways in finished spaces to conceal new cabling that cannot be installed above accessible ceiling or within walls. Use surface raceway only when raceway type and routing are approved by Architect and Owner's representative. Securely support from building construction and secure to masonry surfaces with expansion anchors. Mount at heights at locations shown on Drawings; obtain approval from Architect and Owner's representative for all routing not indicated on Drawings. Do not run surface raceway through walls with plaster finish or through masonry walls or floors. Install pipe sleeve with junction boxes or adapter fittings for raceway runs through these areas. In existing construction, run raceway along top of baseboards, taking care to avoid telephone and other signal wiring around doorframes and other openings. Run raceway on ceiling or walls perpendicular to or parallel with walls and floors.

K. Raceways for Future Use (Spare Raceways and Empty Raceways): Draw fish tape through raceways in Architect's presence to demonstrate that raceway is clear of obstructions. Leave pulling-in line in each spare and empty raceway.

L. Raceway Installation in Special Areas

1. Raceways Exposed to Different Temperatures: Where portions of interior raceway system are exposed to widely different temperatures, seal interior and exterior of raceway to prevent circulation of air from warmer to colder section through raceway installation.

2. Refrigerated Rooms: Install raceway body or junction box in raceway system on warm side of refrigerated room. After cables are installed, seal raceway interior at raceway body or junction box.

3. Heated Areas to Unheated Areas: After cables are installed, seal raceway interior at nearest raceway body, outlet or junction box in heated area adjoining unheated area.

M. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Provide locknuts for securing raceway to metal enclosure with sharp edge for digging into metal and ridged outside circumference for proper fastening.

2. Provide bushings for terminating raceways smaller than 1-1/4 inches with flared bottom and ribbed sides with smooth upper edges to prevent injury to cable insulation.

3. Install insulated type bushings for terminating raceways 1-1/4 inches and larger with flared bottom and ribbed sides and with upper edge with phenolic insulating ring molded into bushing.

4. Provide screw-type grounding terminal for standard or insulated type bushing.

5. Provide miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings and plugs specifically designed for their particular application.

N. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).

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 (70 deg C) temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) 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.

O. Fittings and Accessories Installation

1. Use zinc electroplate or hot dipped galvanized steel fittings and accessories in conjunction with ferrous raceways in dry and damp locations.

2. Use hot dipped galvanized fittings and accessories in conjunction with ferrous raceways in wet locations.

3. Use caps or plugs to seal ends of raceways until cable is installed (to exclude foreign material).

4. Use deflection fittings where raceways cross expansion joints that move in more than one plane.

5. Use 2 locknuts and insulated bushing (plastic bushing on 1/2-inch raceway and 3/4-inch raceway) on end of each raceway entering sheet metal cabinet or box in dry or damp locations. Terminate raceway ends within cabinet/box at same level.

6. Use watertight hub on end of each raceway entering cabinets or boxes (in wet locations) not constructed with integral threaded hubs.

7. Specific Applications:

   a. Galvanized Rigid Conduit: Use threaded fittings and accessories. Use 3-piece raceway coupling where raceway cannot be rotated.
   b. Flexible Metal Raceway: Use flexible metal raceway connectors.
   c. Liquid Tight Flexible Metal Raceway: Use “seal-tite” connectors.

8. Rigid Nonmetallic Raceway, Metal Surface Raceway, and Wireways: Use manufacturer's standard fittings and accessories.

## 3.2 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter or as detailed on drawings.

2. Install backfill as specified in Section 312000 "Earth Moving."

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.

   b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

## 3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes with bottom below 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. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for 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.

## 3.4 EXISTING RACEWAYS

A. Conditions for Re-Use of Existing Raceways:

1. Existing raceway is adequately sized for new cables.
2. Remove existing cables.
3. Demonstrate to Architect that existing raceway is clear of obstructions and in good condition.
4. Install insulated bushings to replace damaged or missing bushings. Replace non-insulated bushings with insulated bushings on raceway sizes 1 inch and larger.

## 3.5 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. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. Install with a maximum of two 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.

## 3.6 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 26 05 33

# SECTION 26 05 44 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 “Penetration Firestopping”.

## PART 2 - PRODUCTS

### 2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, 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 (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.

2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

## 2.2 SLEEVE-SEAL SYSTEMS

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, 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.
e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of raceway. Include type and number required for raceway material and size of raceway.

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: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
D. 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 40 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, nonshrinking 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 raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "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 (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.

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 (50 mm) 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 raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between raceway 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 (25-mm) annular clear space between raceway 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 raceway entries into building.

B. Install 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.

## 3.3 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.
D. Using grout, seal the space around outside of sleeve-seal fittings.

## 3.4 SLEEVE INSTALLATION FOR FIRE RATED ASSEMBLY PARTITIONS

A. 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.

B. Maintain indicated fire rating of walls, partitions, ceilings and floors at raceway penetrations. Install sleeves and sleeve seals with appropriate firestop materials. Comply with Division 07 Section “Penetration Firestopping”.

END OF SECTION 26 05 44

# SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

B. Provide identification on all equipment, raceways, boxes, conductors, and devices.

C. Identification provided should match the identification names, designations, and letters/numbers indicated on drawings, schematic and interconnection diagrams, equipment manufacturer’s shop drawings, and in specifications.

### 1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.
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.

### 1.4 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 and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high letters on 20-inch centers.

D. 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.

E. 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.

F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch-wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

H. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

I. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

## 2.2 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 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, 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.

F. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

## 2.3 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

## 2.4 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.

4. 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 side with the inscription of the utility, compounded for direct-burial service.

5. Overall Thickness: 5 mils.

6. Foil Core Thickness: 0.35 mil.

7. Weight: 28 lb/1000 sq. ft..

8. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

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.

## 2.5 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, nonfading, 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."

## 2.6 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.

## 2.7 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
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.
C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

## 2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg 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 piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

## 2.9 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-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. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. 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.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 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.

J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

### 3.2 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.

3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Cables within Buildings: Identify raceways and 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. Exit lights
3. Power.
4. UPS.

D. 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 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

E. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags.

F. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

G. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

H. 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.

I. 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.

J. 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.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels:

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.

L. 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.

M. 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.

N. 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, user readable identification.

1. Labeling Instructions:

    a. Indoor Equipment: Self-adhesive, 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 lines of text are required, use labels 2 inches high.

    b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, Stenciled legend 4 inches high.

    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. Power, Lighting, and Control:

        1) Switchboards, Panelboards, MCCs, Equipment Cabinets, Control Panels, Generators, UPS Equipment, Battery Inverter Units, Disconnect Switches, Enclosed Circuit Breakers, and Motor Controllers:

            a) Typewritten panelboard directory of circuits in the location provided by panelboard manufacturer.
            b) Provide nameplate with equipment identification as indicated on the drawings.
            c) Indicate source and location of the source.
            d) Provide nominal system voltage designation labels on cover.

        2) Disconnect Switches and Enclosed Circuit Breakers:

            a) Indicate the equipment designation and location which the disconnect serves.

        3) Motor Controllers and VFD's:

            a) Indicate the motor designation, location, and the type of service.

    b. Transfer Switches:

        1) Provide nameplate with equipment identification as indicated on the drawings.
        2) Indicate the equipment designation and location which the transfer switch serves.
        3) Indicate normal and standby/emergency sources and location of the sources.
        4) Provide nominal system voltage designation labels on cover.

c. Pull boxes, Enclosures, Junction Boxes:

1) Provide identification labels with feeder, branch circuit, and control circuit numbers on cover.
2) Indicate source(s) and location(s) of the source(s).
3) Indicate the load(s) and location(s) of the load(s) served.
4) Provide nominal system voltage designation labels on cover.

d. Feeder Circuits, Branch Circuits, Control Circuits, Site Lighting Circuits:

1) Provide cable tags, wire markers, and phase identification tape as appropriate.
2) Identify circuits in each junction box, pull box, outlet box, enclosure, gutter, manhole, handhole, lighting standard base, and at each termination.
3) Identify with circuit number, load and location served, and panel (equipment) designation and location from which it originates.
4) Include identification of the building from which it originates for exterior circuits.

e. Circuits Over 600 Volts:

1) Cables should be identified at each manhole, handhole, junction box, transformer, switch, and at each termination using cable tags.

2) Identify nominal voltage, circuit number, circuit size, load served, and equipment designation and location from which it originates.

3) Exposed conduit runs should be identified continuously similar to "DANGER – 4160 VOLTS", "DANGER – 13,200 VOLTS" or as appropriate.

f. Underground Conduits and Circuits:

1) Provide warning ribbon above the underground installation. The ribbon should be capable of being identified by a metal detector. The ribbon shall include continuous lettering similar to "CAUTION BURIED ELECTRIC BELOW".

g. Empty Conduit Runs and Conduits with Conductors for Future Use:

1) Provide cable tags
2) Indicate proposed future use
3) Label conduits and conductors at both ends, including location of another end.

h. Receptacles, Switches, and Control Devices:

1) Provide identification label on faceplate.
2) Identify branch circuit number and panel designation and location from which it originates.

3) Identify receptacles supplied from GFCI-type circuit breakers as “GFCI Protected”.

i. Emergency Lighting Fixtures:

j. Provide identification labels on ceiling mounted emergency light fixtures, which have integral battery ballast backup or are tied into an emergency power system (i.e. emergency generator, central battery inverter, etc.). Labels should be attached to these fixtures so that they are readily discernible, by a person standing on the normal walking surface in the area, for testing purposes.

3. Normal and Emergency Systems:

a. Equipment Cabinets, Terminal Cabinets, Control Panels, Patch Panels, Racks:

1) Provide nameplates with equipment identification as indicated on the drawings.
2) Label termination blocks and ports.
3) Provide nominal system voltage designation labels on cover

b. Pull boxes, Enclosures, Junction Boxes:

1) Provide identification labels including system type and circuit numbers on cover.
2) Indicate equipment and location(s) from which enclosed cables originate.
3) Indicate the equipment and location(s) of the equipment served.
4) Provide nominal system voltage designation labels on cover.

c. Cables and Conduits:

1) Provide cable tags, wire markers, and identification labels including system type and circuit numbers as appropriate.
2) Identify cables in each junction box, pull box, device box, enclosure, gutter, manhole, handhole, and at each termination.
3) Identify with cable number, equipment and location(s) of the equipment served, and equipment designation and location from which it originates.
4) Label conduits at both ends, including conduit number and location of other end.
5) Include identification of the building from which it originates for exterior cables.

d. Underground Conduits and Cables:

1) Provide warning ribbon above the underground installation. The ribbon shall be capable of being identified by a metal detector. The ribbon shall include continuous lettering similar to “CAUTION BURIED ELECTRIC BELOW”.

e. Empty Conduit Runs and Conduits with Cables for Future Use:

1) Provide cable tags and identification labels.

2) Indicate proposed future use.
3) Label conduits and cables at both ends (including location of other end).

f. Fire Alarm:

1) Fire alarm junction boxes and pull fittings should be painted red to identify them as components of the fire alarm system as compared to other systems.

2) Remote Smoke Detector Lamps and Test Stations – Provide nameplate indicating the location of the connected device.

3) Initiation Devices, Notification Appliances, Fire Alarm Relays – Provide device identification and zone or address identification label.

4) Communication:

a) Comply with applicable EIA, TIA, and ANSI standards.
b) Data Outlets – Provide device identification label on faceplate. Identify equipment designation and location from which it originates.

5) Security:

a) Provide device identification labels.
b) Identify equipment designation and location from which it originates.

g. Access doors and panels for concealed electrical items.

h. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.

END OF SECTION 26 05 53

# SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

1. See especially Section 01 08 00, “General Commissioning Requirements” for general commissioning process requirements and Commissioning Coordinator responsibilities.

### 1.2 SUMMARY

A. Section includes commissioning process requirements for Lighting Control Systems, which are described in more detail in the technical specification 26 09 23 Lighting Control Devices.

### 1.3 DEFINITIONS

A. CxA: Commissioning Authority.

### 1.4 SUBMITTALS

A. Submittals shall comply with the requirements of the Construction Contract Clauses, Section 01 33 00 "Submittal Procedures" and the individual sections specifying the work.
B. Prefunctional Checklists of readiness.
C. Prefunctional Checklists of completion of installation, prestart, and startup activities.
D. Certificates of readiness and completion of installation.
E. Test and inspection reports and certificates.
F. Corrective action documents.
G. Functional Performance Test Procedures

### 1.5 QUALITY ASSURANCE

A. Lighting Control Testing Technician Qualifications: Technicians to perform Lighting Control Construction Prefunctional Checklist verification tests and demonstrations, functional performance tests and demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level in Electrical Testing or Installation. Vocational School four-year program graduate or an Associate’s degree in electrical systems, or similar field. Degree may be offset by three years' experience in servicing electrical systems in the HVAC or Electrical industry.

## 1.6 CONTRACTOR'S RESPONSIBILITIES

A. Provide Electrical work in accordance with contract document requirements for Lighting Control Systems.
B. Perform commissioning tests at the direction of the CxA.
C. Attend construction phase coordination meetings.
D. Attend testing, adjusting, and balancing review and coordination meeting.
E. Participate in Lighting Control systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
F. Provide information requested by the CxA for final commissioning documentation.
G. Provide measuring instruments and logging devices to record test data and provide data acquisition equipment to record data for the complete range of testing for the required test period.

## 1.7 CxA'S AUTHORITY

A. Provide Project-specific construction checklists and commissioning process test procedures for actual Lighting Control systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Directing commissioning.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

## 1.8 COMMISIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Lighting Control system to be verified and tested.
4. Prefunctional Checklists certifying that installation, prestart checks, and startup procedures have been completed.
5. Prefunctional Checklists certifying that Lighting Control systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing and adjusting reports.

PART 2 - EXECUTION

2.1 TESTING PREPARATION

A. Certify that Lighting Control systems have been installed, calibrated, and started and are operating according to the Contract Documents.
B. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

2.2 GENERAL TESTING REQUIREMENTS

A. The CxA in cooperation with the Electrical Contractor shall prepare detailed testing plans, procedures, and checklists for Lighting control systems.

2.3 LIGHTING CONTROL SYSTEMS FUNCTIONAL TESTING PROCEDURES

A. Lighting Control System Functional Testing and Acceptance Procedures:

1. Occupancy Sensor Controls:

a. Certify that the occupant sensor has been located and aimed in accordance with manufacturer recommendations.

b. Each occupancy sensor shall be tested, where applicable.

1) Verify the correct operation of occupant sensor controls status indicators.
2) Verify the controlled lights turn off or down to the permitted level within the required time.
3) Verify the lights turn on to the permitted level when an occupant enters the space for auto-on occupant sensor controls.
4) Verify the lights turn on only when manually activated for manual-on occupancy sensors.
5) Verify the lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

2. Daylight Responsive Controls

a. Verify control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.
b. Verify daylight controlled lighting loads adjust to light level set points in response to available daylight.
c. Verify the locations of calibration adjustment equipment are readily accessible to authorized personal.

B. Provide documentation and certification to the CxA.

C. Lighting Control systems are shown on the contract drawings.

END OF SECTION 26 08 00

# SECTION 26 09 23 - LIGHTING CONTROL DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Daylight-harvesting dimming controls, digital.
2. Indoor occupancy and vacancy sensors.
3. Touch Screen Stations.
4. Low Voltage Controls.
5. Conductors and cables.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

### 1.2 ACTION SUBMITTALS

A. Product Data:

1. Daylight-harvesting dimming controls, digital.
2. Indoor occupancy and vacancy sensors.
3. Touch Screen Stations.
4. Low Voltage Controls.
5. Conductors and cables.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.
c. Daylight-harvesting dimming controls, digital.
d. Touch Screen Stations.

2. Interconnection diagrams showing field-installed wiring.

3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

### 1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's warranties.

1.4 WARRANTY

A. Special Extended Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.

1. Failures include, but are not limited to, the following:

a. Faulty operation of lighting control devices.

PART 2 - PRODUCTS

2.1 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL

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

1. hubbell.
2. Leviton.
3. Steinel.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.

1. Lighting control set point is based on the following two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done with two 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 **integrated** power pack to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Sensor Output: zero to 10 V(dc) to operate luminaires. Sensor is powered by controller unit.

3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

E. Power Pack: Digital controller capable of accepting three 8PSJ inputs with **two** output(s) rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc) Class 2 power source.

1. With integral current monitoring.
2. Compatible with digital addressable lighting interface.
3. Plenum rated.

## 2.2 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Hubbell.
2. Leviton.
3. Steinel.

B. General Requirements for Sensors:

1. Ceiling mounted, solid-state indoor occupancy and vacancy sensors.

2. Dual technology.

3. Integrated power pack.

4. Hardwired connection to switch.

5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

6. Operation:

   a. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Sensor is powered from the power pack

8. Power: Line voltage

9. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.

10. Mounting:

    a. Sensor: Suitable for mounting in any position in a standard device box or 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.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.

12. Bypass Switch: Override the "on" function in case of sensor failure.

13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The technology or combination of technologies that control on-off functions is 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. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/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.

4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. when mounted 48 inch above finished floor.

## 2.3 TOUCH SCREEN STATIONS

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. ETC.
2. Crestron.
3. Leviton.

B. General Requirements:

1. Two-gang sized LCD switch station supports common Dialog Room Controller switching functions.
2. Pre-programmed and configured for use with Dialog Room Controller systems.
3. Kit includes 120Vac 60Hz to 24Vac transformer.
4. Backlight switches OFF automatically after 10 seconds of inactivity.

C. Technical Requirements:

1. Rated Voltage: 200mA 24Vac (from transformer).
2. Signal Current: 15mA.
3. Maximum distance between transformer and the farthest LCD switch: 300ft.
4. Applicable Wires: Power 0.9mm.
5. WR-4040-120.

6. 120Vac Primary.
7. 24Vac Secondary.
8. 40VA steady draw, 40VA pulsed draw.

## 2.4 LOW VOLTAGE CONTROL

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. Douglas Controls.
2. Leviton.
3. ETC Echo.

B. General Requirements:

1. Modern Styling.
2. LED Status Indication.
3. Interchangeable keypads.
4. 2-Wire Dialog for Data and Power.
5. BT Programmable iOS App (free).
6. Touchless Control via iOS Tap-to-Control App (free).
7. •Available in multiple Colours.
8. (White, Grey, Black, Ivory, Light Almond, Red).
9. Custom Laser Etching (optional).

C. Technical Requirements:

1. 4-Button Programmable Dialog Dimmer Switch.
2. Toggle, ON, OFF, Preset Activation, Raise, Lower, Timer.
3. Target: Individual, Groups, Presets (Output, Mode Trigger, Behaviour Trigger).
4. 2-Wire Dialog.
5. LED Status indication.
6. 4.12” x 1.75” x 0.75” (H x W x D) - Installs in standard gang wall boxes.
7. Dialog Dataline (24VAC).
8. Status, Standby Locator, Timer Expiration, Error.
9. Indoor, stationary, non-vibrating, non-corrosive atmosphere, and non-condensing humidity.
10. Operating temperature: 14°F to 140°F (-10°C to 60°C).
11. Storage temperature: -14°F to 140°F (-25° to 60°C).
12. ASHRAE 90.1 Compliant.
13. FCC Compliant.

## 2.5 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 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION OF SENSORS

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 instructions.

### 3.3 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.
C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.4 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

### 3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

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. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Prepare test and inspection reports.

D. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

## 3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two 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.

## 3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 09 23

# SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

### 1.3 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. 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.

### 1.4 CLOSEOUT SUBMITTALS

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

### 1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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 IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

## 1.6 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.

## 1.7 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 with concrete.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

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. Acme Electric Corporation.
2. Challenger Electrical Equipment Corp.
3. Controlled Power Company.
4. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
5. Federal Pacific Transformer Company.
6. General Electric Company.
7. Hammond Co.
8. Magnetek Power Electronics Group.
9. Micron Industries Corp.
10. Myers Power Products, Inc.
11. Siemens Energy & Automation, Inc.
12. Sola/Hevi-Duty.
13. Square D Co./Groupe Schneider NA; Schneider Electric.

## 2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Enclosure: Ventilated, NEMA 250, Type 3R.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

G. Taps for Transformers Smaller Than 3 kVA: None.

H. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

I. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

J. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

K. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

L. 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.

3. Shield Effectiveness:

a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.

b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

M. Wall Brackets: Manufacturer's standard brackets.

## 2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

## 2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

# 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 260526 "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. Brace wall-mounting transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

## 3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

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. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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 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. 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 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. 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 26 22 00

# SECTION 26 24 16 - PANELBOARDS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Lighting and appliance branch-circuit panelboards.
2. Disconnecting and overcurrent protective devices.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard including switching and overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. 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. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. 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.

C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," 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.

## 1.6 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.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

## 1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. 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.

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. Comply with NEMA PB 1.

E. 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 minus 22 deg F to plus 104 deg 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.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

## 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 with concrete.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted 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 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 Noncorrosive Liquids: NEMA 250, Type 5.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Finishes:

a. Panels and Trim: Steel and galvanized 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: Surface mount, same finish as panels and trim. Flush mount, galvanized steel.

4. Directory Card: Inside panelboard door, mounted in transparent card holder.

B. Incoming Mains Location: Top or bottom as required.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity. 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. 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.

4. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

5. Extra-Capacity Neutral Bus: Where indicated, neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

## 2.2 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."

## 2.3 DISTRIBUTION PANELBOARDS

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. 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.

D. Mains: Circuit breaker, fused switch, lugs only, as indicated on 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; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

G. Contactors in Main Bus: NEMA ICS 2, Class A, electrically 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. External Control-Power Source: 120-V branch circuit.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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. 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 indicated on 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, electrically 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. External Control-Power Source: 120-V branch circuit.

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.

## 2.5 LOAD CENTERS

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. 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. Load Centers: Comply with UL 67.

C. Mains: Circuit breaker or lugs only, as indicated on drawings.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

## 2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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. 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. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

4. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.

b. Lugs: Mechanical 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. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.

g. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

## 2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

# 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. Install panelboards and accessories according to NECA 407. Comply with NECA 1.

B. Equipment Mounting: Where size of distribution panelboard requires, install distribution panelboards on concrete bases, 6-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

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 floor mounted distribution 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 distribution panelboards.
5. Attach distribution panelboards to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Mount top of trim 90 inches above finished floor, unless otherwise indicated, and after ensuring the operating handle of the top-most switch or circuit breaker, in on position, is not higher than 79 inches (2000 mm) above the finished floor or grade.

F. Mount panelboard cabinet plumb and rigid without distortion of box.

G. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

H. Install overcurrent protective devices and controllers not already factory installed.

I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

J. Install filler plates in unused spaces.

K. Stub two 1-inchempty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub two 1-inchempty conduits below slabs not on grade.

L. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

## 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

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 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

## 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. 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. 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. 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 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

# SECTION 26 27 26 - WIRING DEVICES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Snap switches.
3. Cord and plug sets.
4. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.
5. Cord reels for receptacles

### 1.3 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. TVSS: Transient voltage surge suppressor.
F. UTP: Unshielded twisted pair.

### 1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

### 1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

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; Division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

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 stranded building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

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

a. Cooper; 5351 (single), CR5362 (duplex).
b. Hubbell; HBL5351 (single), HBL5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5361 (single), 5362 (duplex).

B. 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; IG5362RN.
b. Hubbell; IG5362.
c. Leviton; 5362-IG.
d. Pass & Seymour; IG5362.

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.

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

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. Cooper; TR8300.
b. Hubbell; HBL8300SGA.
c. Leviton; 8300-SGG.
d. Pass & Seymour; TR63H.

2. Description: Labeled shall comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

D. USB Charger Duplex Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

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. Cooper; TRUSBAC20W-BOX.
b. Hubbell; USB20AC.
c. Leviton; T5834.
d. Pass & Seymour; TR20USBAC6W.

2. Description: Straight blade receptacle with (1) USB-A charging port and (1) USB-C charging port.

## 2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed and non-feed-through type.

2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 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. Cooper; VGF20.
b. Hubbell; GFR5352L.
c. Pass & Seymour; 2095.
d. Leviton; 7590.

C. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 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. Hubbell; GFTR20.
b. Pass & Seymour; 2095TR.

## 2.5 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.

2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.6 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 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. Single Pole:

1) Cooper; AH1221.
2) Hubbell; HBL1221.
3) Leviton; 1221-2.
4) Pass & Seymour; CSB20AC1.

## 2.7 WALL PLATES

A. Single and combination types shall 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 and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

C. Cover Plates:

1. Stainless Steel Cover Plates: Type 302 or 304, satin finish, 0.040 inch thick, accurately die cut, protected with release paper. Flush mounting plates shall be beveled with smooth rolled outer edge. Surface mounting plates shall be beveled and pressure formed for smooth edge to fit box. Single and combination plates as required to match types and sizes of specified wiring devices.

2. Weatherproof Cover Plates: Receptacles in wet locations shall be installed with a hinged outlet cover/enclosure clearly marked “Suitable For Wet Locations While in Use” and “UL Listed”. There must be a gasket between the enclosure and the mounting surface, and between the hinged cover and the mounting plate/base to assure proper seal. The installation shall be in compliance with NEC Article 406.9.

3. Dust Tight Cover Plates: Receptacles in non-hazardous, high dust environments shall be installed with a gasketed, spring door cover that closes tightly automatically to protect receptacle from dust and dirt when not in use. With plug inserted, a heavy-duty gasket in the throat of the receptacle shall seal around the plug body to keep out dust and dirt. The cover shall be suitable for mounting to standard FS/FD surface or flush mounted boxes. Suitable for all NEMA configuration receptacles and toggle switches. Appleton FSK-W series or approved equal.

D. Material for unfinished spaces: Galvanized steel.

## 2.8 CORD REEL

A. Cord Reel for Receptacle

1. Standard duty cord reel constructed with oversize main shaft, bearings, and main spring; heavy gauge cable drum and housing. High capacity slip rings, oversize brushes, and copper graphite contact points, anchored in floating brush holder.

2. Instant action automatic lock providing positive foolproof stop at desired point, regardless of mounting position or speed of retraction

3. Convert easily to constant tension by rotating external control

4. Lead-in and working cables of No. 14 AWG 250 volt oil resisting safety yellow SJO cord.

5. Large internal radius of cable guide casting to prevent snubbing and abrasion of cable.

6. External tension adjustment to permit spring tension to be increased or decreased to meet job requirements.

7. Lifetime lubricated, self-contained main motor springs.

8. Declutching feature to eliminate breakage on rewind.

9. 35 ft. of 3-conductor cable.

10. Similar to "Cord Reel No. 990" by Daniel Woodhead Company.

B. Receptacle Box

1. Compact, "NeoTex" rubber compound, oil-proof and resistant to most chemicals.
2. Soft rubber, non-injurious to personnel or machinery; safe around electrical contacts.
3. Furnished with two NEMA 5-15 duplex receptacles.
4. Similar to "Box No. 3000-1" by Daniel Woodhead Company.

C. Cord Reel with Hand Lamp

1. Standard duty cord reel constructed with oversize main shaft, bearings, and main spring; heavy gauge cable drum and housing. High capacity slip rings, oversize brushes, and copper graphite contact points, anchored in floating brush holder.

2. Instant action automatic lock providing positive foolproof stop at desired point, regardless of mounting position or speed of retraction.

3. Convert easily to constant tension by rotating external control.

4. Lead-in and working cables of No. 14 AWG 250 volt oil resisting safety yellow SJO cord.

5. Fluorescent lamp ballast located in lead-in cable.

6. Switch located in handle.

7. Large internal radius of cable guide casting to prevent snubbing and abrasion of cable.

8. External tension adjustment to permit spring tension to be increased or decreased to meet job requirements.

9. Lifetime lubricated, self-contained main motor springs.

10. Declutching feature to eliminate breakage on rewind.

11. 30 feet of 3-conductor cable.

12. Shockproof, butyrate plastic shield to protect fluorescent lamp and guard against shattering.

13. Oil-proof safety yellow “NeoTex” rubber handle and end cap seal around plastic shield.

14. Double insulated construction of handle, cord set, and ballast.

15. Similar to “Cord Reel No. 990-83” by Daniel Woodhead Company.

## 2.9 FINISHES

A. 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.

B. Wall Plate Color: For plastic covers, match device color.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. 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 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 right 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 devices that have been in temporary use during construction and that 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 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by 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 down, 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. 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. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

## 3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

## 3.3 CORD REELS

A. Mount on single channel bracket similar to “Globe Strut G-5032” with top of bracket 10 feet above finished floor.
B. Plug lead-in cable into receptacle located 6 inches to left of bracket at same height as bracket.

## 3.4 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

## 3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display 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 5 percent or higher is unacceptable.

3. Ground Impedance: Values of up to 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. 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.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 27 26

# SECTION 26 32 13 - ENGINE GENERATORS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. Gas engine.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Outdoor enclosure.

B. Related Sections include the following:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

### 1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Time-current characteristic curves for generator protective device.

B. 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. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Wiring Diagrams: Power, signal, and control wiring.

## 1.5 INFORMATIONAL SUBMITTALS

A. Source quality-control test reports.

1. Certified summary of prototype-unit test report.

B. Field quality-control test reports.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

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 each of lubricating oil, fuel, and combustion-air filters.

## 1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. 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.

E. Comply with ASME B15.1.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

I. Comply with UL 2200.

J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

## 1.9 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than 7 days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 3000 feet.

## 1.10 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

## 1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 4 years from date of Substantial Completion.

1.12 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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. Caterpillar; Engine Div.
2. Generac Power Systems, Inc.
3. Kohler Co.
4. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Output Connections: Three-phase, four wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10, system requirements.

## 2.3 ENGINE

A. Fuel: Natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Natural Gas System:

a. Carburetor.
b. Fuel-Shutoff Solenoid Valves: One for each fuel source.
c. Flexible Fuel Connectors: One for each fuel source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

   a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

5. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

6. Fan: Driven by multiple belts from engine shaft.

7. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.

J. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.

7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

    a. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

## 2.4 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

C. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Start-stop switch.
11. Overspeed shutdown device.

12. Coolant high-temperature shutdown device.
13. Coolant low-level shutdown device.
14. Oil low-pressure shutdown device.
15. Generator overload.

D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

E. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.

F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

G. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.
2. Lube-oil, low-pressure shutdown.
3. Overspeed shutdown.
4. Remote emergency-stop shutdown.
5. Engine high-temperature prealarm.
6. Lube-oil, low-pressure prealarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.

H. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

I. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

## 2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

## 2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

## 2.7 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

C. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

## 2.8 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.9 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

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

## 3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

## 3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
B. Connect fuel piping to engines with a gate valve and union and flexible connector.
C. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 221623 "Facility Natural-Gas Piping."
D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

## 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. Report results in writing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

c. Verify acceptance of charge for each element of the battery after discharge.

d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Remove and replace malfunctioning units and re-inspect as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

J. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

## 3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 26 32 13

# SECTION 26 36 00 - TRANSFER SWITCHES

## 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. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Bypass/isolation switches.
2. Remote annunciator system.
3. Remote annunciator and control system.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.

2. Include material lists for each switch specified.

3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

### 1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Certificates: For transfer switches, 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.

C. Field quality-control reports.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

## 1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.

a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

## 1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

## 1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Transfer 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. Caterpillar; Engine Div.
b. Emerson; ASCO Power Technologies, LP.
c. Generac Power Systems, Inc.
d. GE Zenith Controls.
e. Kohler Power Systems; Generator Division.
f. Onan/Cummins Power Generation; Industrial Business Group.
g. Russelectric, Inc.

2.2 PERFORMANCE 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. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for three cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Neutral Terminal: Solid and fully rated unless otherwise indicated.

M. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

N. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.

O. Battery Charger: For generator starting batteries.

1. Float type, rated 10 A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

P. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

Q. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

R. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.3 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.

2. Switch Action: Double throw; mechanically held in both directions.

3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.

4. Conductor Connectors: Suitable for use with conductor material and sizes.

5. Material: Tin-plated aluminum.

6. Main and Neutral Lugs: Compression type.

7. Ground Lugs and Bus-Configured Terminators: Compression type.

8. Ground bar.

9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.

2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

3. Fully automatic break-before-make operation with center off position.

4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.

2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.

3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

a. Initiation occurs without active control of generator.

b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.

c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

F. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

G. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

H. Electric Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

I. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

J. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

K. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.

2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.

6. Switch-Position Pilot Lights: Indicate source to which load is connected.

7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.

12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

L. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.

3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

## 2.4 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using contactor-based components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Tin-plated aluminum.
6. Main and Neutral Lugs: Compression type.
7. Ground Lugs and Bus-Configured Terminators: Compression type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.

2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

3. Fully automatic break-before-make operation with center off position.

4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.

2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.

3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.

a. Initiation occurs without active control of generator.

b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.

c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.

4. Failure of power source serving load initiates automatic break-before-make transfer.

F. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

G. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

H. Electric Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

I. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

J. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

K. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.

L. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.

2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.

6. Switch-Position Pilot Lights: Indicate source to which load is connected.

7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.

12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is unavailable.

M. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.

3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

## 2.5 TRANSFER SWITCH ACESSORIES

A. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.

2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.

3. Annunciation panel display shall include the following indicators:

a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
b. Switch position.
c. Switch in test mode.
d. Failure of communication link.

4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

a. Indicating Lights: Grouped for each transfer switch monitored.
b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
d. Lamp Test: Push-to-test or lamp-test switch on front panel.

B. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.

2. Include the following functions for indicated transfer switches:

a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
b. Indication of switch position.
c. Indication of switch in test mode.
d. Indication of failure of digital communication link.
e. Key-switch or user-code access to control functions of panel.
f. Control of switch-test initiation.
g. Control of switch operation in either direction.
h. Control of time-delay bypass for transfer to normal source.

3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:

a. Controls and indicating lights grouped together for each transfer switch.
b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
c. Digital Communication Capability: Matched to that of transfer switches supervised.
d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

## 2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for legally required systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.

d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

3. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

### 3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 271500 "Communications Horizontal Cabling."

F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

G. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

## 3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment, test for compliance with requirements according to NETA ATS.

2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with Drawings and Specifications.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and required clearances.

d. Verify that the unit is clean.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

f. Verify that manual transfer warnings are attached and visible.

g. Verify tightness of all control connections.

h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.

j. Verify positive mechanical interlocking between normal and alternate sources.

k. Perform visual and mechanical inspection of surge arresters.

l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

a. Perform insulation-resistance tests on all control wiring with respect to ground.

b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.

c. Verify settings and operation of control devices.

d. Calibrate and set all relays and timers.

e. Verify phase rotation, phasing, and synchronized operation.

f. Perform automatic transfer tests.

g. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.

    b. Simulate loss of phase-to-ground voltage for each phase of normal source.

    c. Verify time-delay settings.

    d. Verify pickup and dropout voltages by data readout or inspection of control settings.

    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.

    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.

D. Coordinate tests with tests of generator and run them concurrently.

E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Transfer switches will be considered defective if they do not pass tests and inspections.

G. Remove and replace malfunctioning units and retest as specified above.

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

## 3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

# SECTION 26 51 19 - LED INTERIOR LIGHTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Downlight.
2. Surface mount, linear.
3. Suspended, linear
4. Cylinder.
5. Exit Signs
6. Miniature Emergency Inverters
7. Materials.
8. Luminaire support.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

### 1.3 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.

### 1.4 ACTION SUBMITTALS

A. 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 IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project ES LM-79and 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.

## 1.5 CLOSEOUT SUBMITTALS

A. 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.

## 1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications:

1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

2. 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.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 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: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 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. 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.

C. Recessed luminaires shall comply with NEMA LE 4.

D. California Title 24 compliant.

2.2 DOWNLIGHT

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

1. Utopia.
2. Finelight
3. HE Williams.

B. Nominal Operating Voltage: 120 V -277 V ac.

C. Lamp:

1. Minimum lumens - refer to luminaire schedule.

2. Minimum allowable efficacy of 90.

3. CRI of 80 CCT of 3500k.

4. Rated lamp life of 50,000 hours to L70.

5. Dimmable from 0-10 percent to zero percent of maximum light output.

6. Internal driver.

7. User-Replaceable Lamps:

   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61.

8. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

E. 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.

F. Diffusers and Globes:

1. Fixed lens.
2. Batwing light distribution.
3. UV-stabilized acrylic
4. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
5. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.

2. RoHS compliant.

3. UL Listing: Listed for damp location.

4. Recessed luminaires shall comply with NEMA LE 4.

5. Internal driver.

6. User-Replaceable Lamps:

   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61

7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

H. Housings:

1. Extruded-aluminum housing and heat sink.

2. Clear anodized finish.
3. With integral mounting provisions.

I. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

J. Diffusers and Globes:

1. Tempered Fresnel glass.
2. Acrylic Diffusers: One 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.

K. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

## 2.3 SURFACE MOUNT, LINEAR

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

1. Amerlux.
2. Finelight.
3. Luminii

B. Nominal Operating Voltage: 120 V – 277 V ac.

C. Lamp:

1. Refer to luminaire schedule.

2. Minimum allowable efficacy of 90 lm/W.

3. CRI of 80 CCT 3500K.

4. Rated lamp life of 50,000hours to L70.

5. Dimmable from 0-10 percent to zero percent of maximum light output.

6. Internal driver.

7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying withANSI C81.61

8. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Powder-coat finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. UV-stabilized acrylic
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

## 2.4 SUSPENDED, LINEAR

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

1. Amerlux.
2. Finelight.
3. Luminii

B. Nominal Operating Voltage: Nominal Operating Voltage: 120 V – 277 V ac

C. Lamp:

1. Refer to luminaire schedule.

2. CRI: Refer to luminaire schedule.

3. Rated lamp life of 50,000 hours to L70.

4. Dimmable from 100 percent to zero percent of maximum light output.

5. Internal driver.

6. User-Replaceable Lamps:

   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61and IEC 60061-1.

7. 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.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. UV-stabilized acrylic.
2. Acrylic Diffusers: One 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.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

## 2.5 CYLINDER

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

1. Lightheaded.
2. Intense Lighting

B. Nominal Operating Voltage: Nominal Operating Voltage: 120 V – 277 V ac.

C. Lamp:

1. Minimum 2100 lm.

2. Minimum allowable efficacy of 80.

3. CRI of 80CCT of 35000.

4. Rated lamp life of 50,000 hours to L70.

5. Dimmable from 100 percent to zero percent of maximum light output.

6. Internal driver.

7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61.

8. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. UV-stabilized acrylic.
2. Acrylic Diffusers: One 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.

G. With integral mounting provisions.

H. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

## 2.6 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. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

    a. Battery: Sealed, maintenance-free, nickel-cadmium type.

    b. Charger: Fully automatic, solid-state type with sealed transfer relay.

    c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

    d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

    e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

    f. 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.

    g. 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.

3. Master/Remote Sign Configurations:

    a. Master Unit: Comply with requirements above for self-powered exit signs and provide additional capacity in battery for power connection to remote unit.

    b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

## 2.7 MINIATURE EMERGENCY INVERTERS

A. Provide UL 924 listed, NFPA 101 compliant maintenance-free sealed lead acid battery miniature inverters that are designed to provide power to emergency luminaires that are suitable for damp installations with LED test switch and are inclusive of the following functions:

1. Automatic output voltage select
2. Automatic dimming (0-10V) relay of connected emergency luminaires under emergency lighting conditions
3. Switched and dimmed inputs are passed through the miniature emergency inverter to the downstream emergency luminaires under normal power conditions
4. Removable/replaceable electronics module
5. Works with LED and fluorescent fixtures

6. Ideal for (but not limited to) screw-base LED lamps
7. Compatible with AC (line voltage) driven TLED lamp
8. Remote-mounting up to 1,000 feet maximum
9. 24 hour recharge time
10. Minimum VA ratings of 250 VA

## 2.8 LUMINAIRE SCHEDULE

A. Refer to Luminaire Schedule on Drawings.

## 2.9 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" 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/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.
D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

# 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 luminaire installation.
C. 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 a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. 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 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 two locations, spaced near corners of luminaire.

G. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

## 3.4 IDENTIFICATION

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

## 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 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

C. Remove and replace with new, all broken glassware, plastic or fixtures damaged before final acceptance at no additional expense to Owner.

D. No allowance made for breakage or theft before final acceptance.

E. Immediately prior to occupancy, damp clean all diffusers, glassware, fixture trims, reflectors, lamps, and replace burned- out lamps.

## 3.7 STARTUP SERVICE

A. Verify all luminaires function in conjunction with lighting control system and perform as intended.

1. Illumination is adequate and measured satisfactorily.
2. Dimming performs satisfactorily in accordance with specification.
3. 1 Hour of training of Owner includes technical information about luminaires and is completed in conjunction with lighting control specification.

## 3.8 UTILITY REBATES

A. Provide Owner with all receipts for the light fixtures, luminaires, etc. eligible for current utility rebate programs at completion of Contract, allowing Owner to apply for rebates and schedule utility company inspections. Provide copy to Architect for record.

END OF SECTION 26 51 19

# SECTION 26 55 61 – THEATRICAL LIGHTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 WORK INCLUDED

A. Supply and test a complete theatre lighting and lighting control system as specified herein for areas indicated on the Drawings and circuit schedules.

B. Install the complete theatre lighting and lighting control system as specified herein for areas indicated on drawings and circuit schedules.

1. Furnish all conduit, wire, connectors, hardware, and other incidental items necessary for the complete and proper operation of the lighting control system.

2. Coordinate all work described in this Section with all other applicable plans and specifications, including, but not limited to:

a. General Conditions.
b. Electrical Section General Provisions.
c. Conduit.
d. Wire and cable.

### 1.3 SUMMARY

A. System Description: The system shall be designed for the control of architectural and theatrical lighting and shall consist of factory pre-wired dimming and processing rack enclosures containing dimmers, relays, power supplies, breakers, terminals and/or control electronics.

1. Replace existing dimmer control board, dimmers.
2. Replace existing house light control.
3. Provide theatrical lighting as specified.

B. System shall work in conjunction with specified low-voltage control stations.

### 1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Dimmer racks 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.

## 1.5 SUBMITTALS

A. Manufacturer shall provide 4 sets of full system submittals, including:

1. Full system riser diagrams illustrating interconnection of system components, wiring requirements, back box sizes and any special installation considerations.
2. Full set of printed technical data sheets.
3. Detailed set of dimmer schedules.
4. Detailed set of circuit and control schedules, including a complete list of all deviations from specifications.
5. Manufacturer shall provide any additional information, including equipment demonstrations, as required by Engineer to verify compliance with specifications.

## 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fixtures, distribution components, software operating manuals, instructional videotapes, and controls to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Control-Console Introduction:

    a. Descriptions of controls and features.
    b. Software instruction manuals.
    c. Setup requirements for unit and related equipment.
    d. Default settings.
    e. Maintenance procedures and schedules.

2. Control-Console Operation:

    a. Elementary on-off operation.
    b. How to set cues manually.
    c. How to patch dimmer to channels electronically.
    d. How to operate two-scene presets manually.
    e. How to operate fundamental memory.
    f. How to set and record simple cues.
    g. How to recall, play back, and revise cues and scenes.
    h. How to use submasters, and how to split cues, store and recall programs, set up special effects, and print out cues.
    i. How to set up and run system for a typical event or performance.
    j. How to get help.

3. Dimming Racks:

    a. Descriptions of features, functions, and safety and security precautions.

    b. Descriptions of dimmer module features, dipswitches, non-dim functions, and racking systems.

c. How to check loads against dimmer capacity ratings.

d. How to set basic power-in and power-out connections.

e. Basic maintenance requirements, including need for qualified electrician for internal maintenance; basic maintenance schedule; techniques for keeping terminals properly tightened, filter screens clean, and overheat sensors checked; and techniques for performing other required servicing.

f. How to adjust control cards.

g. How to get help.

h. Description of warranty.

4. System Troubleshooting: Procedures for handling problems with common software, programming, control console, dimmer rack, and distribution system; include information on how to get help.

B. 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 if applicable.
4. Printout of software application and graphic screens.

## 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.

1. Dimmer Modules: One of each type and rating installed.
2. Fuses: Three of each kind.

## 1.8 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall be one who has been continuously engaged in the manufacture of lighting control equipment for a minimum of 10 years. All dimmer and cabinet fabrication must take place in a U.S. manufacturing plant.

1. The manufacturer shall have a factory authorized stocking service center with at least one full time service technician on call.. In addition, the manufacturer shall have a toll free 24-hour hotline with a maximum response time of 20 minutes, 24-hours a day and 365 days a year.

2. All equipment, where applicable standards have been established, shall be built to the standards of Underwriter's Laboratories, Inc., the National Electrical Code and the United States Institute for Theatre Technology. Permanently installed power distribution equipment such as dimmer racks and distribution shall be UL and C-UL listed, and/or CE marked (where applicable) and bear the appropriate labels. Portable equipment such as consoles and fixtures shall be UL and C-UL listed, ETL listed and/or CE marked (where applicable) and bear the appropriate labels.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Manufacturers:

1. Subject to compliance with requirements, provide products by:

   a. Electronic Theatre Controls, P.O. Box 620979, Middleton, Wisconsin 53562

      1) Phone: 608-831-4116

   b. Strand Lighting, 6603 Darin Way, Cypress, CA 90630

      1) Phone: 714-230-8200

2. Alternative manufacturers must submit a full pre-approval package 10 days prior to Bid date. Package shall consist of items listed in Part 1, Section 1.5A.

3. Permission to bid does not imply acceptance of the manufacturer. It is the sole responsibility of the Electrical Contractor to ensure that any price quotations received, and submittals made are for controls systems that meet or exceed the specifications.

### 2.2 INTELLIGENT BREAKER SYSTEM

A. General

1. Intelligent breaker system shall be 120V Sensor IQ as manufactured by ETC, Inc., or equal.

2. Breaker Panels shall be UL508, UL67, and UL924 Listed, and shall be so labeled when delivered.

3. Breakers shall be UL489 listed and shall be labeled when delivered.

4. Breaker Panels shall consist of a main enclosure with 12, 24, or 48 pole breaker subpanels, integral control electronics for low voltage terminations and provision for accessory cards.

   a. Up to two accessory cards shall be supported per breaker panel.

B. Mechanical

1. The panel shall be constructed of 16-gauge galvannealed steel. All panel components shall be properly treated or finished in fine-textured, scratch resistant paint

2. Breaker panels shall be capable of being mounted on the surface of a wall or recessed mounted

3. Breaker panels shall be available in 12, 24, and 48 pole configurations

   a. 12 pole MLO (No provision for main Breaker)

      1) 31 inches high, 14.25” wide and 4” deep (with front panel attached)

   b. 12 pole (with provision to add main breaker)

      1) 40.25 inches high, 14.25” wide and 4” deep (with front panel attached)

   c. 24 pole (with provision to add main breaker)

      1) 50.25 inches high, 14.25” wide and 4” deep (with front panel attached)

   d. 48 pole (with provision to add main breaker)

      1) 64 inches high, 20” wide and 5.25” deep (with front panel attached)

4. Choice of panel covers shall be available for surface or recess mount applications. This outer panel shall ship complete with a locking door to limit access to electronics and breakers.

   a. Optional center-pin reject security screws shall be available for all accessible screws.
   b. Optional recess mount doors shall extend 1” beyond all panel edges to hide wall cut-out.

5. The unit shall provide interior cover over the control electronics and accessory cards to allow access only to class 2 wiring and prevent direct access to class 1 line voltage components.

6. The panel shall support up to twelve, twenty-four, or 48 single pole branch circuits.

   a. Branch circuits shall range from 15A to 30A capable of holding full rated load for minimum of three hours continuously.

   b. Two and three-pole circuits shall be supported at decreased density where each pole constitutes one of the available single-pole circuits. Mixing of circuits in any combination shall be supported.

7. Breakers shall provide manual switching control while power is unavailable to the panel such that critical lighting can be set to an on state, without the need for power to the panel.

8. Breaker output lugs shall accept 10-14 AWG dual conductor wire.

9. Breaker output lug shall support solid or stranded 6-14 AWG class B, C, or K copper wire.

10. Control wiring for DMX, station bus, and Emergency input terminations shall land on a removable header for contractor installation.

C. User Interface

1. The user interface shall contain an LCD display with button pad to include 0-9 number entry, up, down back arrow navigation and enter.

2. Test shortcut button shall be available for local activation of preset, sequence and set level overrides.

3. The user interface shall have a power status LED indicator (Blue), a DMX status LED indicator (Green), a network status LED indicator (Green) and an LED indicator (red) for errors.

4. Interface shall allow the backlight to timeout and shall provide user editable options to shut off backlight completely as well as adjust screen contrast.

5. Ethernet interface shall default to automatic IP through link local and DHCP. Upon receiving IP address, the address of the Network Interface Card (NIC) shall display in the about menu. Static address and settings shall also be possible.

6. The control interface shall support a USB memory stick interface for uploads of configurations and software updates.

7. The user interface shall support power input from an external Uninterruptible Power Supply (UPS) supplying 800W-2400W AC power.

D. Functional

1. Panel setup shall be user programmable. The control interface shall provide the following breaker setup features (per circuit):

   a. Type (1 pole, 2 pole, or 3 pole)

   b. Name

   c. Circuit Number

   d. DMX address

   e. sACN address

   f. Space Number

   g. Circuit Modes

      1) Normal (priority and HTP based activation and dimming)
      2) Latch-lock
      3) Fluorescent
      4) DALI

   h. On threshold level

   i. Off threshold level

j. Include in UL924 emergency activation

k. Allow Manual

2. Breaker panels shall support discrete addressing of each breaker. Panels that are restricted to use of start address with sequential addressing, and cannot assign each 0-10V output control to any internal circuit shall not be acceptable

3. The panel shall be capable of switching 6 poles on or off at once, or in a user-selectable delay per breaker using a period of 0.1 to 60 seconds, in 0.1 second increments

4. An Ethernet connection shall provide advanced control of relays over streaming ACN (sACN) and transmit status, control override, and measured energy usage per branch circuit via an internal Web UI or central monitoring interface

   a. Control electronics shall report the following information per branch circuit.

      1) Breaker state (On/Off)
      2) Breaker state (Open/Closed)
      3) Current draw (In Amps)
      4) Voltage
      5) Energy usage

   b. Panels that do not report this information shall not be acceptable.

5. Built-in Control shall include:

   a. Ability to record up to 16 presets in each space from the control panel, connected control stations, or timed events

   b. Presets shall be programmable by recording current levels (as set by DMX or connected control stations), by entering levels on the control panel directly, manually selecting breaker state on each breaker, or a combination of these methods. From the control panel, stations, or timed events it shall be possible to record values for up to 16 zones per space

   c. Up to 8 spaces in a single rack for total of up to 16 spaces shall be supported per system or system subnet

   d. Indication of an active preset shall be visible on the control panel display

   e. One 16-step sequence per space for power up and power down routines

   f. The panel shall have a UL924-listed contact input for use in Emergency Lighting systems. The panel shall respond to the contact input by setting included breakers to “on”, while setting non-emergency breakers “off”. Each breaker can be selected for activation upon contact input.

   g. Upon Data loss the system shall provide options to hold last look infinitely or hold for a configured time period set by the installing technician then fade/switch to the input of the next available priority

h. Control electronics shall respond directly to control stations for zone, preset, and sequence control. Systems that require secondary control systems for this functionality are not acceptable.

i. After power loss, electronics shall be capable of holding the system in its previous state until new level data (DMX, architectural presets, sequences and zones, or local overrides) is received to make each breaker change state.

6. The control of lighting and associated systems via timed and Astronomical clock controls

a. The breaker panel shall allow the activation of presets, sequence, and zone programming of up to 50 time clock events via a built in real and astronomical time clock

b. System time events shall be programmable via the control panel.

1) Time clock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday

2) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event.

3) System shall automatically compensate for regions using a fully configurable daylight saving time.

4) Presets shall be assigned to events at the time clock.

c. The time clock shall support event override.

1) It shall be possible to override the timed event schedule form the face panel of the time clock.

d. The time clock shall support timed event hold.

1) It shall be possible to hold a timed event from the face panel of the processor.

7. The panel shall receive ESTA DMX512-A control protocol. Addressing shall be set via the user interface button keypad with any circuit patched to any DMX control address.

a. 2,500V of optical isolation shall be provided between the DMX512 inputs and the control electronics as well as between control and power components

b. The breakers shall respond to control changes (DMX or Stations) in less than 25 milliseconds. DMX512 update speed shall be 40Hz.

c. Setting changes shall be able to be made across all, some, or just one selected breaker in a single action from the face panel.

d. DMX data loss shall allow for levels/breakers to be held for ever or for a specified time before switching to a lower priority source.

e. Initial Panel setup

1) The breaker panel shall automatically detect the type of breaker or dimmer installed in each location without need for manual configuration of the physical arrangement.

2) Quick rack setup shall be available to apply address settings across all circuits for rack number, DMX Start Address, sACN universe, and sACN start address.

3) Emergency Setup Menu shall provide optional delays when emergency is activated or deactivated, and option to turn off non-emergency circuits shall be available. Record function shall allow circuits that are turned on to be added to the emergency setting.

E. Electrical

1. Breaker Panels shall be available to support power input from:

a. 120/208V three phase 4-wire plus ground
b. 120/240V single phase 3-wire plus ground

2. Conduit Entry:

a. Feeders:

1) Top or upper 6” of either side
2) Bottom or lower 6” of either side
3) Feeders shall enter through the top or bottom according to the orientation of the enclosure.
4) Feeder entry shall be nearest to the location of the feeder lugs or main breaker.

b. Load:

1) Load wiring shall enter through the top or bottom of the enclosure through the surface nearest to the breaker sub panel

2) Load wiring may also enter through left and/or right side provided a low voltage chase is not required through the same area. If class 2 chase is required, a field installable barrier panel shall be provided upon request. The side of the panel where the barrier has been installed shall not permit load wiring

c. Low Voltage:

1) Top or upper 6” of either side
2) Bottom or lower 6” of either side
3) For low voltage conduit entry at the breaker end of the cabinet, conduits shall be located at the outer 3” of the top/bottom panel

3. Breaker

a. Bus connection type: Stab on

b. 1, 2, or three poles

c. UL489 listed

d. 15 amp, 20 amp, or 30 amp

e. 22,000 SCCR; 65,000A series rated with main breaker

f. High inrush trip curve (matches all Sensor breakers)

g. Maintains trip curve through entire thermal range

h. Guaranteed not to trip at full load

i. Load lugs accept 6-14awg load wiring

j. Multi-conductor listed output terminal

k. Integral mechanically held air gap relay

l. Manual control of relay state using breaker handle w/o power

m. Integral current sensing

n. Integral position and trip sensing

o. Control and status provided by contact pads directly at bottom of the breaker case

p. No external wires or connections required for control or feedback

q. The breaker shall be capable of switching up to 30A

r. The breaker panel shall support a maximum feed size

1) 100 Amps at 12 circuits
2) 200 Amps at 24 circuits
3) 400 Amps at 48 circuits

s. Breaker panels shall support main circuit breaker options:

t. Main breaker options shall be optional and available for purchase upon request

u. Main breakers shall be field installable

v. Main breakers shall be available in up to 100 Amps for 12 circuit panels, up to 200 Amps for 24 circuit panels, and up to 400A for 48 circuit panels at 120V

w. Series SCCR ratings apply as follows with appropriate main breaker:

1) 22,000A or 64,000 at 120/208V

x. Main breakers shall allow the following range of wire sizes:

1) Up to 300kcmil at 100A and 200A
2) Up to 2x250kcmil at 400A

y. Main Lug input shall support up to 2x250kcmil

z. Breaker panel shall support a 500kcmil main lug option for 48-circuit panels

F. Breaker remote switching ratings

1. Mechanical 1,000,000 cycles
2. 24A Resistive 100,000 cycles
3. 16A Ballast (HID) 75,000 cycles
4. 15A Electronic (LED) 100,000 cycles
5. 15A Tungsten 45,000 cycles
6. 30FLA; 180 LRA Motor Load 50,000 cycles
7. Tested duty cycle: 12 operations (6 cycles) per minute
8. Decreasing duty cycle significantly increases switch life
9. Isolation: 4000V RMS
10. Current reporting accuracy: 5%
11. Latching state mechanical relay

G. Breaker Panel Accessories

1. A low voltage 0-10V dimming option shall provide up to 24 0-10v control outputs that are linked to relay circuits within the panel. Each output shall support up to 400mA of current sink per output

2. A contact input option shall provide 24 dry contact inputs to be linked for direct or group relay control, to activate a preset, or to activate a sequence. Controller software shall allow for normally open maintained, normally closed maintained, or momentary toggle

3. A DALI control option shall provide 24 control loops of broadcast DALI control, with each loop controlling up to 64 DALI devices

4. A RideThru option shall provide short-term power backup of control electronics by automatically engaging when power is lost, and recharging when normal power is present

5. An Isolated Ground option shall provide each circuit in the panel with a ground terminal that is electrically isolated from the equipment ground

6. Main Breaker options shall be available as shown in Section E.4

H. Thermal

1. The panel shall be convection cooled. Panels that require the use of cooling fans shall not be acceptable
2. The panel shall operate safely in an environment having an ambient temperature between 32ºF (0ºC) and 104ºF (40°C), and humidity between 5-95% (non-condensing)

## 2.3 ARCHITECTURAL CONTROL PROCESSOR MODULES

A. Control Processor Modules

1. The Architectural Control Processor shall be the Unison Paradigm Series, P-ACP Control Processor as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. The Architectural Control Processor (ACP) assembly shall be designed for use in DRd Series Power Enclosures and ERn Series Control Enclosures.

b. The processor shall utilize microprocessor based, solid state technology to provide multi-scene lighting and building control.

c. ACP module electronics shall be contained in a plug-in assembly.

1) The module shall be housed in a formed steel body and contain no discrete wire connections.

a) No tools shall be required for module removal or insertion.

d. The ACP shall be convection cooled.

e. User Interface

1) The ACP shall utilize a backlit liquid crystal display capable of graphics and eight lines of text.

2) The ACP shall provide an alpha-numeric keypad for data entry and navigation.

3) The ACP shall provide a touch-sensitive control wheel for navigation.

4) The ACP shall provide shortcut buttons to assist in navigation, selection, and data entry.

5) The ACP keypad, buttons, and wheel shall be backlit for use in low-light conditions.

a) The backlight shall have a user selectable time out, including no time out.

6) The ACP shall provide a front-panel RJ45 receptacle for Ethernet connection to the processor for configuration, live control, and web-browser-based system access.

a) The RJ-45 receptacle shall be secured behind the locking door.

7) The ACP shall provide a Secure Digital (SD) Removable Media slot on the front panel for transfer of configuration data.

a) The SD slot shall be secured behind the locking door.

8) The ACP shall provide a Universal Serial Bus (USB) port on the front panel for transfer of configuration data.

a) The USB port shall be secured behind the locking door.

9) Architectural Lighting System configuration and program information shall be stored in flash memory, which does not require battery backup.

a) The ACP shall provide a Compact Flash (CF) Card as backup flash memory and storage.
b) The CF Card is located in the back of the ACP, and can be accessed only by removing the ACP.
c) The ACP data can be exchanged by inserting the CF card into another ACP.

3. Electrical

a. The ACP shall require no discrete wiring connections; all wiring shall be terminated into Dimming or Control Enclosure.

b. The ACP shall require low-voltage power supplied by the Dimming or Control enclosure.

c. The ACP shall be hot-swap capable.

d. The ACP shall support Echelon LonTalk with LinkPower communications with control stations and other remote devices, including button stations, button/fader stations, Touchscreen stations, sensors, and third party LonMARK compliant products.

1) The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit. Touchscreen stations, interface stations and portable stations connectors will also require (2) #16 AWG wires.

2) The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.

3) Link power wiring shall permit a total wire run of 1640 ft. (500m) without a repeater. Repeater option modules shall be available to increase wiring maximums in increments of 1640 ft. (500m).

4) Link power wiring between stations shall not exceed 1313 ft. (400m).

e. The ACP shall support 10/100BaseTX, auto MDI/MDIX, 802.3af compliant Ethernet networking using TCP/IP, ESTA BSR E1.17 Advanced Control Networks (ACN) and ESTA BSR E1.31 (sACN) Protocols for internal communication and integration with third-party equipment.

f. The ACP shall support EIA-RS232 serial protocol for bi-directional command and communication with third-party equipment.

g. The ACP shall support two discrete ESTA DMX512A ports, configurable as input or output ports.*

1) *When used in a Dimming Enclosure, the second port is always an output port.

h. The ACP shall provide four onboard dry contact closure inputs for integration with third-party products.

i. The ACP shall provide four onboard contact closure outputs, rated at 1A@30VDC, for integration with third-party equipment.

4. Functional

a. Capacity

1) Shall support 1024 channels of control
2) Shall support 2 physical DMX ports, each of which may be configured as an input or output

b. System

1) Runtime application shall utilize support Net3 system interoperability

2) System shall support the use of Network Time Protocol for real time clock synchronization

3) System shall support remote firmware upload an over Ethernet connection from a connected PC running the Light Designer software or another connected processor.

4) System shall support local firmware upload from removable media (SD Card, USB Flash Drive)

c. Diagnostics

1) Shall output an Event log
2) Standard log shall store a fixed-length history of recent activity
3) Separate critical log shall only store important messages (such as boot-up settings)

d. Configuration Data

1) Configuration Data can be uploaded over an Ethernet connection from a PC running Light Designer application
2) Configuration Data can be retrieved from another Paradigm Processor
3) A Paradigm Processor shall make its configuration data available for retrieval by another Processor as a backup/recovery mechanism
4) Configuration Data shall be stored on solid-state media that can be removed to facilitate transfer between Processor units
5) Configuration Data may be loaded to and from removable media access provided on front panel

6) Configuration Data for the entire System shall be available for download from any single Processor
7) Shall store configuration data for Dimming enclosure processors and shall make available for download

e. Scalability

1) Adding additional Processors to a System shall proportionately increase its overall capabilities up to a maximum project size

2) The maximum number of Processors configured as a project shall be at least 12. The use of a Central Control Processor (P-CCS) shall allow for larger system sizes up to 72 processors

3) Multiple Processors shall utilize the Ethernet network to remain time synchronized and share control information

4) Multiple Processors shall utilize the Ethernet network to maintain configuration data synchronization as modifications are made

5) Failure of a single Processor shall not prohibit continuing operation of the remaining Processors

6) It shall be possible for multiple Systems to coexist on the same physical network with logical isolation between Systems

f. Local User Interface

1) Shall provide access to Processor setup (IP address)
2) Shall provide access to Processor status and diagnostics
3) Where the Processor is installed within a Dimming enclosure, shall provide access to Dimming enclosure setup, status and diagnostics
4) Shall provide control functionality for Control Channels, Zones, Fixtures, Groups, Presets, Macros, Walls and Sequences within the current configuration.
5) Shall provide functionality to schedule astronomical and real time events (add/edit/delete)
6) Shall allow for display of local DMX information
7) Shall allow for transfer of log files to local removable media
8) Shall allow to perform firmware upgrades for connected Dimming enclosures
9) Shall allow for transfer of configuration to and from Dimming enclosures using removable media
10) Shall allow for transfer of configuration to and from LCD Stations using removable media
11) Shall allow for binding of Stations

g. Access Controls

1) There shall be 2 user accounts - Administrator, and User with separate password protection
2) Account and password settings shall be local to each Processor

3) Access Controls shall be applied to certain areas of the Paradigm Local User Interface and Web Interface

h. Web User Interface

1) Shall be an internal web server accessible via Ethernet port
2) Shall support common web browsers on Windows and Mac platforms
3) Shall provide functionality to Activate and Deactivate Presets
4) Shall provide functionality to schedule timed events (add/delete)
5) Shall display status information
6) Shall display log files
7) Shall allow for configuration of Processor settings (date, time)
8) Shall allow for upload and download of configuration data
9) There shall be links to other web-enabled devices in the System, including other Paradigm Processors

i. Stations

1) Stations shall be connected to a Paradigm Processor via a LinkPower network or Ethernet
2) Station discovery and binding shall be accomplished from the Local User Interface or Light Designer

j. Net3 and ACN Devices

1) Paradigm Processors shall provide DMX-Net3 gateway functionality
2) Net3 devices shall be connected to and controlled from the Processor via Ethernet
3) It shall be possible to send and receive Macro triggers defined within the System configuration via Net3
4) There shall be support for a maximum of 1024 Streaming ACN outputs configured to a maximum of 12 universes per Processor

k. Operation

1) When contained in an dimming enclosure, a snapshot of the dimming enclosure output data shall be stored in persistent memory so that hardware can access it for immediate output on boot

2) DMX output refresh rate shall be configurable

3) There shall be support for 16-bit DMX Attributes

4) DMX inputs may be patched to DMX and Streaming ACN outputs as external sources

5) Streaming ACN inputs shall be patched to DMX outputs (gateway) as external sources

6) Where there are multiple external sources then priority and HTP shall be used to perform arbitration

7) External and internal sources shall be arbitrated based on user-selection of standard or custom rules

8) On Preset Record, the values of Attributes within the Preset shall be updated to reflect the current output

9) The total output may be the combination of many different Presets running concurrently

10) There shall be no hard limit on number of concurrent cross fades

11) Multiple Presets controlling the same Attribute shall first interact based on priority and second based on Latest Takes Precedence (LTP) or Highest Takes Precedence (HTP)

12) LTP and HTP operation shall be supported simultaneously and interact (at the same priority) using HTP

13) Settings due to LTP Presets may be automatically discarded from operation when overridden

14) It shall be possible to specify that a Preset or Attribute Control will persist when overridden

15) A Preset may be designated as an HTP Override and shall cause HTP values to be discarded

16) It shall be possible to modify the rate of a Preset (Cross fades, Effects) from a Control within the System

17) Each Preset shall have a status that can be Activated, Deactivated or Altered

18) Preset status may be set based on matching levels in the current output as an option

19) On startup the System shall be capable of automatically executing timed events within the previous 24 hours to synchronize its initial output state with the current time of day

l. Serial Input/Output

1) RS232 shall support 8-bit word length, parity selection and 1 or 2 stop bits
2) RS232 shall support baud rates from 4800 to 115,200 bps
3) Serial input and output messages are fully customizable
4) Serial output messages can be generated by any Control or Event

## 2.4 STATION PROCESSOR MODULES

A. The Station Power Module shall be the Unison Paradigm P-SPM Series Station Power Module as manufactured by Electronic Theatre Controls, Inc., or equal.

B. Mechanical

1. The Station Power Module (SPM) assembly shall be designed for use in DRd Series or ERn Rack Enclosures.

2. The SPM shall convert input power into low-voltage (Class II) power with data line and a secondary auxiliary low-voltage line to energize button, button/fader, touchscreen, and interface devices for multi-scene lighting and building control.

3. SPM module shall be contained in a plug-in assembly.

   a. The module shall be housed in a formed steel body and contain no discrete wire connections.

      1) No tools shall be required for module removal or insertion.

4. The SPM shall be convection cooled.

5. User Interface

   a. The SPM shall utilize light emitting diodes (LED's) to indication function, status and fault.

6. The SPM shall be secured behind the locking door.

7. Wall-mounted, direct wire and 19" rack-mount, connectorized repeater and dual-repeater variants shall be available from the same manufacturer where required on the project.

C. Electrical

1. The SPM shall require no discrete wiring connections; all wiring shall be terminated into the dimming enclosure, unless required by a variant.

2. The SPM shall require line-voltage power supplied by the contractor, terminated inside the dimming or control enclosure.

3. The SPM shall be hot-swap capable.

4. The SPM, in conjunction with a matching Architectural Control Processor (ACP), shall support Echelon LinkPower communications with remote devices, including button, button/fader, touchscreen and interface stations, and shall interoperate with LonMARK-approved third-party devices.

   a. The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit.

   b. The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.

c. Link power wiring shall permit a total wire run of 1640 ft. (500m)

1) Repeaters allow an additional wire run of 1640 ft. (500m)
2) Dual-repeaters allow two additional wire runs of 1640 ft. (500m)

d. Link power wiring between stations shall not exceed 1313 ft. (400m).

5. The SPM shall support auxiliary power for certain remote devices, including touchscreen and interface stations, as required by the device.

a. The auxiliary power network shall utilize polarity-dependent, low-voltage Class II wiring, consisting of two # 16 AWG wires.

b. Auxiliary wiring shall permit a total wire run of 1640 ft. (500m)

1) Repeaters allow an additional wire run of 1640 ft. (500m)
2) Dual-repeaters allow two additional wire runs of 1640 ft. (500m)

c. The SPM shall supply 1.25 amps at 24v DC continuously.

D. Functional

1. Capacity

a. Each SPM shall:

1) Supply power for up to 32 button and button/fader stations.

a) Repeaters and dual-repeaters allow 30 additional stations, 62 total

2) Supply auxiliary power for a similar number of interface stations.

3) Shall supply auxiliary power for up to four Touchscreen stations, when a like number of other stations are deducted from the total.

a) Repeaters and dual-repeaters allow two additional Touchscreens (six total) when a like number of other stations are deducted from the total.

2. Operation

a. The SPM shall not require configuration or programming.

b. The SPM shall automatically detect faults in the wiring, indicate the fault, including the fault polarity, and shut down the output power.

1) The SPM shall automatically reset when the fault is clear, and can be manually reset by removing and re-inserting the module.

## 2.5 UNISON ERN SERIES CONTROL ENCLOSURES

A. Control Enclosures

1. The control enclosure shall be the Unison ERn Series Control Enclosure as manufactured by Electronic Theatre Controls, Inc., or equal.

B. Mechanical

1. The External Processing enclosure shall be a surface mounted panel constructed of 18 gauge formed steel panels with a hinged, lockable full-height door containing an integral electrostatic air filter.

    a. The enclosure door shall have an opening to allow limited access to the control module face panel.
    b. Enclosures shall be convection cooled without the use of fans.

2. Control Enclosures shall be sized to accept one or two Control Processors and one or two Station Power Modules, including various options and accessories.

    a. The Control Enclosure for a single control processor (ERn2) shall support a single Station Power Supply module; The Control Enclosure for 2 control processors (ERn4) shall support a quantity of 2 modules.

3. All enclosure components shall be properly treated and finished.

    a. Exterior surfaces shall be finished in fine textured, scratch resistant, powder based epoxy paint.

4. Enclosure(s) shall also be available in a 19” rack mounted (RM) version.

    a. Rack-mounted version shall have an independent enclosure suspension kit, with a full height, locking door/cover attached to the kit.
    b. Rack-mounted version shall have an opening to access the control module face panel, and openings to view indicators on option modules.

5. Enclosure dimensions and weights (without modules) shall not exceed:

    a. ERn2 - 15” W x 9” H, 10” D, 15 lb.
    b. ERn2-RM - 19” W 11”H 10” D, 20 lb.
    c. ERn4 - 15” W x 14” H x 10” D, 20 lb.
    d. ERn4-RM - 19” W x 16” H x 10” D, 25 lb.

6. Top, bottom, and side knockouts shall facilitate conduit entry.

7. Enclosures shall be designed to allow easy insertion and removal of all control and option modules without the use of tools.

    a. Supports shall be provided for precise alignment of modules into power and signal connector blocks.
    b. With modules removed, enclosures shall provide clear front access to all power and control wire terminations.

8. Option Modules

a. Ethernet Switch

1) The Control Enclosure shall support an optional 5-port Ethernet Switch, with at least 4 ports supplying Power over Ethernet (PoE).

2) The Ethernet Switch module shall be 100BaseTX, auto MDI/MDIX, 802.3af PSE compliant.

3) The Ethernet Switch module shall contain power, status, and activity indicators. All indicators shall be visible when the enclosure door is open for both rack and wall mounted ERn.

b. Redundant Power Supply (RRPS)

1) The Control Enclosure shall support an optional redundant power supply which shall automatically provide power to the control electronics upon failure or removal of the primary power supply.

2) The redundant power supply shall assert itself seamlessly without a loss of power to the control electronics.

3) The redundant power supply shall seamlessly remove itself when the primary power supply is reengaged.

4) The redundant power supply shall provide visible indication that it is active.

c. Station Bus Repeaters (ERn4 only)

1) The Control Enclosure shall support an optional module to expand the station bus length an additional 400 meters, and the station count an additional 30 stations (60 maximum per processor/enclosure)

2) Wall-mount and 19" Rack-Mount versions shall also be available to support mid-span insertion away from the Control Enclosure.

d. Station Bus Dual Repeaters (ERn4 only)

1) The Control Enclosure shall support an optional module to expand the station bus length to two additional 400 meter segments (a total of 1200 meters from a single enclosure, and the station count to 60 stations (60 maximum per processor/enclosure).

2) Wall-mount and 19" Rack-Mount versions shall also be available to support mid-span insertion away from the Control Enclosure.

9. Accessories

a. RideThru Option (RTO)

1) The Control Enclosure shall support an optional, short-term back-up power source for the control electronics.

2) RideThru Option (RTO) provides power for controls electronics during brief power outages or drop outs.

3) The short-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.

4) The short-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.

5) The short-term back-up power source shall support the control electronics for at least 10 seconds.

b. BatteryPack Option (BPO)

1) The Control Enclosure shall support an optional, long-term back-up power source for the control electronics.

2) The long-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.

3) The long-term back-up power source shall supply power to the control electronics for at least 90 minutes.

4) The long-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.

5) A test switch/indicator shall be available without opening the rack door or removal of any modules/components.

C. Electrical

1. External Processing enclosures shall be available in 100, 120, 230 and 240 volt, single-phase configurations.

2. External Processing enclosures shall be completely pre-wired by the manufacturer. The contractor shall provide input and control wiring.

3. External Processing enclosures shall be designed to support the following wire terminations:

a. AC (single phase)

b. Echelon link power (Belden 8471 or equivalent)

c. 24Vdc (2- 16AWG Wire)

d. DMX512A Port A (In or Out) (Belden 9729 or equivalent)

e. DMX512A Port B (In or Out) (Belden 9729 or equivalent)

f. RS232 Serial In/Out (Belden 9729 or equivalent)

g. Unshielded Twisted Pair (UTP) Category 5 Ethernet

h. Contact Closure In (14AWG to 26AWG Wire)

i. Contact Closure Out (14AWG to 26AWG Wire)

1) Contact Closure Out shall provide 1A @ 30vDC

4. Station Power Modules

a. Station power supply modules shall provide LinkPower for at 32 stations and 1.5A@24VDC of Auxiliary (AUX) power.

b. Station power repeater modules shall provide LinkPower for 30 stations and1.5A@24VDC of Auxiliary (AUX) power.

c. Station power module shall support over-current/short protection for LinkPower and Aux. LinkPower shall support fault detection on each leg of the balanced data bus.

5. All control wire connections shall be terminated via factory provided connectors.

D. Thermal

1. Ambient room temperature: 0-40°C / 32-104°F
2. Ambient humidity: 10-90% non-condensing

## 2.6 TOUCHSCREEN CONTROL STATIONS

A. The Touchscreen Control Stations shall be the Unison Paradigm Touchscreen P-TS7 Series Control Stations as manufactured by ETC, Inc., or equal.

B. General

1. Touchscreen stations shall support default and fully graphical control pages.
2. The Touchscreen station shall operate using graphic buttons, faders and other images on at least 30 separate programmable control pages.
3. Touchscreen stations shall also allow programming of page pass-code, lock out and visibility levels.

C. Mechanical

1. Touchscreen stations shall consist of a seven inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels and 24-bit color depth with a capacitive touch interface.

2. Touchscreen bezels shall be constructed of cast aluminum finished in a fine texture powder coat.

    a. Touchscreen shall be available in five standard colors

        1) Cream (RAL 9001)
        2) Ivory (RAL 1015)
        3) Gray (RAL 7001)
        4) Black (RAL 9004)
        5) Signal White (RAL 9003)

    b. The bezel shall have no visible means of attachment.

    c. The bezel shall allow the touchscreen to be installed and removed without the use of tools.

    d. The bezel shall provide two working positions for the Touchscreen: service and normal operation.

3. Touchscreen shall offer optional hinged locking covers

    a. Locking covers shall be made from cast aluminum and be painted to match standard touchscreen color options
    b. Locking covers shall allow for viewing of system status on the touchscreen though a smoked Lexan window

4. The manufacturer shall provide back boxes for all LCD stations.

    a. Flush back box for Touchscreens with or without locking covers shall be 7.94” wide x 5.33” high x 3.25” deep
    b. Surface back box dimensions shall be 8.3” wide x 5.6” high x 2.75” deep
    c. Surface back box for Touchscreens with locking cover dimensions shall be 10.0” wide x 6.7” high x 2.75” deep

D. Electrical

1. Touchscreens shall be powered entirely by the System network.

2. Touchscreens shall connect to the System using an Ethernet network with Power over Ethernet (PoE) or the Unison control station Echelon® Link power network.

    a. Ethernet Network

        1) Ethernet network shall be 10/100BaseTX, auto MDI/MDIX, 802.3af (PoE) compliant.
        2) Network shall utilize Unshielded Twisted Pair (UTP) Category 5, or better wiring.

3) PoE power consumption shall be PoE class 2, consuming no more than 6 watts.

b. Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Touchscreen stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

3) Network wiring may be bus, loop, home run, star or any combination of these.

4) Network insulation displacement connectors shall be provided with all stations.

E. Functional

1. System

a. The Touchscreen shall support configuration firmware upload from a Paradigm Processor as proxy
b. The Touchscreen shall support configuration or firmware upload from local removable media

2. Setup Mode

a. There shall be a setup display that is separate from any user-defined configuration
b. It shall be possible to view and modify connectivity settings
c. It shall be possible to view status information
d. It shall be possible to view and modify LCD screen settings
e. It shall be possible to perform Touchscreen calibration
f. It shall be possible to view and modify audio settings
g. The appearance of the setup display shall be standard and not editable
h. The setup display may be invoked from within the user-defined configuration and/or physical button on the Touchscreen
i. There shall be a default protected method to invoke the setup display

3. Configurations

a. It shall be possible to have multiple configurations stored within an LCD Station
b. Where multiple configurations are stored there shall be a boot menu to allow selection of a configuration

4. Operation

a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Touchscreen controls. System shall allow the control of presets, sequences, macros and time clock events.

1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.

a) Presets shall have a discrete fade time, programmable from zero to 84,600 seconds with a resolution of one hundred milliseconds.
b) Presets shall be selectable via Touchscreen stations.

2) System macros and sequences shall be programmable via LightDesigner system software.

a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.

3) System time clock events shall be programmable via the Touchscreen, LightDesigner system software, the processor user interface, or the internal web server.

a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.

b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

4) A Color picker, supporting Hue, Saturation and Brightness (HSB) color selection shall be available for color selection of color changing fixtures and provide visual feedback of the current color produced by the associated fixture.

a) The color picker shall be provided with a default layout that requires no user configuration
b) The Color Picker shall provide RGB faders in addition to the default HSB color wheel for color selection
c) Color picker values shall allow for numerical value input in addition to color wheel and fader control
d) The color picker shall be compatible with color mixing systems that use up to seven discrete color control channels

b. Touchscreen stations shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.

1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, and cue light, or room join/separate.

2) Optional fader functions include master control, individual channel control, fade rate control or preset master control.

c. Touchscreen stations shall allow programming of station and component electronic lockout levels via LightDesigner.

d. It shall be possible to adjust LCD contrast and brightness.

e. It shall be possible to program the station to dim during periods of inactivity.

## 2.7 STATIONS

A. Button Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. Unison Heritage Button stations shall operate using up to ten programmable buttons.

b. All button stations shall be available with white, cream, ivory, gray or black faceplates, and buttons.

1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.

c. Stations shall have indicator lights at each button or fader.

1) Indicators shall be comprised of red, green and blue LED's
2) Indicator color and state (steady On, Blink, Off) shall be configured in software, and shall operate relative to the button or fader it is associated with.

d. All faceplates shall be designed for flush or surface mounting.

e. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.

f. Station faceplates shall be indelibly marked for each button or fader function.

g. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.

h. All Button stations shall be shall be designed to accept the infrared signal from a remote hand held IR transmitter.

1) The stations shall have a 60° reception angle and shall operate reliably within a 45' distance.

i. IR Transmitters shall be available in five or ten button configurations.

1) IR transmitters shall be mounted in a hand-held black plastic controller.
2) Transmitter dimensions shall be 1.875” wide, 6.625” long and 0.60” deep.

3. Electrical

a. Unison control station wiring shall be an Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Network wiring may be bus, loop, home run, star or any combination of these.

3) Wiring termination connectors shall be provided with all stations.

b. Button Stations shall offer the following Regular markings

1) UL and cUL LISTED
2) CE Market
3) RHoS and WEE Compliant

4. Functional

a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.

1) System presets shall be programmable via Button stations, Touchscreen stations, and LightDesigner software.

a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
b) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.

2) System macros and sequences shall be programmable via LightDesigner system software.

a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.

3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.

a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.

b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.

1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.

2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

B. Fader Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. Unison Heritage Fader Stations shall operate using up to sixteen programmable faders and twelve programmable buttons.

b. All fader stations shall be available with white, cream, ivory, gray or black faceplates, fader knobs, and buttons.

1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.

c. Fader stations shall utilize standard 45-millimeter slide potentiometers.

d. Stations shall have indicators lights at each button or fader.

1) Indicators shall be comprised of red, green and blue LED's
2) Indicator color and state (steady On, Blink, Off) shall be configured in software, and shall operate relative to the button or fader it is associated with.

e. All faceplates shall be designed for flush or surface mounting.

f. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.

g. Station faceplates shall be indelibly marked for each button or fader function.

h. The manufacturer shall supply back boxes for flush mounted half gang stations and for all surface mounted stations.

i. Fader stations shall be shall be designed to accept the infrared signal from a remote hand held IR transmitter.

1) The stations shall have a 60° reception angle and shall operate reliably within a 45' distance.

j. IR Transmitters shall be available in five or ten button configurations.

1) IR transmitters shall be mounted in a hand-held black plastic controller.
2) Transmitter dimensions shall be 1.875” wide, 6.625” long and 0.60” deep.

3. Electrical

a. Unison control station wiring shall be an Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

3) Network wiring may be bus, loop, home run, star or any combination of these.

4) Wiring termination connectors shall be provided with all stations.

b. Fader Stations shall offer the following Regular markings

1) UL and cUL LISTED
2) CE Market
3) RHoS and WEE Compliant

4. Functional

a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface, or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.

1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.

a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
b) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.

2) System macros and sequences shall be programmable via LightDesigner system software.

a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.

b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.

3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.

a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.

b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.

1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.

2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

c. Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

C. Portable Plug-in Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. Unison connector stations shall provide an interface to portable Unison stations.

b. All connector stations shall be available with white, cream, ivory, gray or black faceplates.

1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.

c. All faceplates shall be designed for flush or surface mounting.

d. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.

e. Station faceplates shall be indelibly marked with station function.

f. The manufacturer shall supply back boxes for all surface mounted stations.

3. Electrical

   a. Unison control station wiring shall be an Echelon® Link power network.

      1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

      2) Portable plug-in stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

      3) Network wiring may be bus, loop, home run, star or any combination of these.

      4) Wiring termination connectors shall be provided with all stations.

   b. Portable Plug-in Stations shall offer the following Regular markings

      1) UL and cUL LISTED
      2) CE Market
      3) RHoS and WEE Compliant

4. Functional

   a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Button, Button/Fader, and Interface or Astronomical time clock controls. System shall allow the programming of presets, sequences, macros and time clock events.

      1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.

         a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
         b) Presets shall be selectable via button, fader, IR transmitter, time clock event, macro activation or switch interface stations.

      2) System macros and sequences shall be programmable via LightDesigner system software.

         a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
         b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.

      3) System time clock events shall be programmable via LightDesigner system software, the processor user interface, or the internal web server.

         a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.

b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.

1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.

2) Optional fader functions include manual master control, individual zone control, fade rate control or preset master control.

D. Locking Covers

1. The Lighting Control Station Locking Covers shall be the Unison Heritage UH Series as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. Locking covers shall be available in Sliding Locking for flush mount applications and Hinged Locking for flush and surface mount applications

b. Sliding Locking Covers shall:

1) Be available with white, cream, ivory, gray or black faceplates.
2) Be constructed of Extruded Aluminum with ABS plastic end caps
3) Provide a smoked Plexiglas window to allow for viewing control status and use of IR remote without opening cover

c. Hinged locking covers shall:

1) Be available in standard black powder coat finish
2) Be constructed of 18 gauge steel and finished in standard black powder coat paint, or custom color as specified.
3) Provide a clear Plexiglas window to allow for viewing control status and use of IR remote without opening cover
4) Use internal Hinge that is not accessible when the cover is closed

d. Standard colors shall conform to the RAL CLASSIC Standard.

e. Locking covers of the same type shall be keyed alike

f. The manufacturer shall supply back boxes for all hinged locking covers.

3. Functional

a. All locking covers shall utilize 90-degree locking mechanisms

1) Keys shall be held captive in locks when covers are unlocked.

b. Locking covers shall allow for easy viewing of system status without opening the cover

c. Locking covers shall support IR remote activation of configured system functions without opening door

## 2.8 INTERFACE STATIONS

A. Portable Plug-in Stations

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. Mechanical

a. Unison connector stations shall provide an interface to portable Unison stations.

b. All connector stations shall be available with white, cream, ivory, gray or black faceplates.

1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard.

c. All faceplates shall be designed for flush or surface mounting.

d. Station faceplates shall be constructed of ABS plastic and shall use no visible means of attachment.

e. Station faceplates shall be indelibly marked with station function.

f. The manufacturer shall supply back boxes for all surface mounted stations.

3. Electrical

a. Unison control station wiring shall be an Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Portable plug-in stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

3) Network wiring may be bus, loop, home run, star or any combination of these.

4) Wiring termination connectors shall be provided with all stations.

b. Portable Plug-in Stations shall offer the following Regular markings

1) UL and cUL LISTED
2) CE Market
3) RHoS and WEE Compliant

B. Contact Interface Station

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. General

a. Unison Contact Interface shall provide direct interface (in and out) to external devices via contact closure. Interface enclosure shall consist of 8 input connections and 8 output connections.

3. Mechanical

a. Contact Interface Stations shall be available in enclosures built for:

1) Wall-mount
2) Rack-mount

b. Wall-mount Interfaces shall be:

1) Designed for surface mount installation
2) Shall be constructed of 16- gauge (.08) steel and are finished in black fine-texture powder coat paint.
3) The enclosure shall be 14” W x 10.5” H x 3” D.
4) Conduit access points shall be provided on the top and bottom of the enclosure.

c. Rack-mount Interfaces shall be:

1) Designed of use in 19” rack-mount enclosures
2) Rack tray shall be constructed of 12-gauge aluminum.
3) Cover shall be constructed of 14- gauge (.08) steel.
4) Rack-mount interfaces shall be finished in black fine-texture powder coat paint.
5) The enclosure shall be 14” W x 10.5” H x 3” D.

d. The assembly shall consist of up to 16 connections; 8 inputs functionally coupled with 8 normally open relay contact outputs. Inputs and outputs may be configured as either maintained or momentary.

4. Electrical

a. Unison control station wiring shall be an Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Contact Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

3) Network wiring may be bus, loop, home run, star or any combination of these.

4) Wiring termination connectors shall be provided with all stations.

b. Ratings:

1) The Input Rating shall be 5V@10mA (unit requires dry contact closure)

2) Dry contact outputs shall consist of:

a) Normally-Open 2-pole contact closure outputs;

1A@30Vdc.
.5A@120V

c. Contact Interface Stations shall offer the following Regular markings

1) UL and cUL LISTED
2) CE Market
3) RHoS and WEE Compliant

C. Fader Interface Station

1. The Lighting Control Stations shall be the Unison Heritage UH Series Control Stations as manufactured by Electronic Theatre Controls, Inc., or equal.

2. General

a. Unison Fader Interface shall provide direct interface for low voltage analog inputs to external devices. Interface enclosure shall consist of 8 input connections.

3. Mechanical

a. The surface mount enclosure and cover shall be constructed of 16- gauge (.08) steel and finished in black fine-texture powder coat paint.
b. The enclosure shall be 14" W x 10.5" H x 3" D.
c. Conduit access points shall be provided on the top and bottom of the unit.
d. The assembly shall consist of up to 8 analog connections functionally coupled to 8 Lamp driver outputs

4. Electrical

a. Unison control station wiring shall be an Echelon® Link power network.

1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

2) Touchscreen and Interface stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.

3) Network wiring may be bus, loop, home run, star or any combination of these.

4) Wiring termination connectors shall be provided with all stations.

b. Ratings:

1) The Input Rating shall be 0-3.3 VDC
2) Lamp driver outputs shall be individually rated for 100mA @ 24 VDC
3) Connections between fader inputs and lamp outputs shall support distances up to 1000 feet using standard 16-gauge wire.

c. Fader Interface Stations shall offer the following Regular markings

d. UL and cUL LISTED

e. CE Market

f. RHoS and WEE Compliant

## 2.9 CONFIGURATION AND CONTROL SOFTWARE

A. System Configuration

1. The Unison Paradigm LightDesigner software program shall be an application software package that facilitates off-line Unison Paradigm control system configuration. LightDesigner shall also enable a computer to be connected on-line with a Unison Paradigm lighting control system for real time preset selection, editing and recording.

a. Software setup shall include Configuration and Space (Room) Wizards, Zone, Preset, Sequence, Station and Wall Properties, Touchscreen Station Setups, Time clock Events and Macros.

b. The software program shall be supplied complete with Operators Manual and software disk.

2. Functions

a. Configuration and Room Wizards

1) The software shall provide easy step-by-step wizards to allow configuration of rooms, channels, walls and control stations.

2) The program shall allow setup of all system parameters including quantity of rooms, dimmers, zones, presets and control stations. System limitations shall be based on system's Unison processor.

3) System program shall support a graphic display of individual rooms, showing zones, presets, control stations and moveable wall placement. Systems with non-graphic displays shall not be acceptable.

4) Software shall support the programming and operation of multi-sectioned rooms with moveable partitions.

5) LightDesigner shall support the programming of station and component electronic security.

6) LightDesigner shall support the transfer of architectural system configurations to processors via Secure Digital (SD) Cards, USB Flash Drives, or Ethernet.

b. Zone, Preset, Station and Wall Properties

1) LightDesigner shall support the configuration of system zone properties. Configurable zone properties shall include zone name, input mode, dimmer to zone patch, and maximum and minimum zone levels.

2) LightDesigner shall support the configuration of system-preset properties. Configurable preset properties shall include preset name and fade time. Presets shall have a discrete fade time, programmable from zero to 86,400 seconds with a resolution of one hundred milliseconds.

3) LightDesigner shall support the custom programming of control station buttons and faders. Button function assignments shall include Preset (last action, pile on, or toggle), Off, Manual, Zone, Record, Raise, Lower, Wall (toggle or direct) Lockout (toggle or direct), No Action, and Macro. Button properties shall include Lockout Level and Legend. Fader assignments shall include Zone, Preset, Master, and Fade time. Fader properties shall include Lockout Level and Legend.

4) LightDesigner shall support the configuration of system wall properties. Configurable wall properties shall include wall name.

c. Time clock Events and Macros

1) LightDesigner software shall support the programming of Astronomical Time Clock (ATC) events for up to ten standard day types and up to 24 custom day types. ATC events include selection of presets or macros. ATC events shall be triggered by sunrise, sunset, time of day and/or periodically.

2) LightDesigner software shall support the programming of multifunction macro sequences. Macros shall be activated via buttons on any Unison station, or via time clock event.

B. Touchscreen Station Configuration

1. The Unison Paradigm ControlDesigner software program shall be an application software package that facilitates off-line Unison Paradigm Touchscreen station configuration.

a. Software setup shall include Configuration and Design Wizards, to create a graphical representation of a control environment.
b. The software program shall be downloadable from the manufacturer's website free of charge.

2. Functions

a. Touchscreen Setup shall include standard or custom control pages. Standard page types shall include zone, preset, wall, or security.

b. Each page may contain graphic objects including buttons, straight or curved faders, and other graphic controls. Pages may also contain imported bitmap images, pop-up windows, animations, numeric keypads, tabs, and clocks.

c. Object Assignments shall include any Action assignable within the System.

d. It shall be possible to adjust LCD contrast and brightness. It shall also be possible to program the station to dim to any level during periods of inactivity.

C. Minimum Computer Requirements

1. The software shall require the following minimum requirements:

a. Windows 8, Windows7 or Windows XP SP2 operating system
b. 2 GHz Pentium 4 or better
c. A minimum of 1 GB system memory
d. A minimum of 1 GB hard drive space
e. OpenGL graphics acceleration with a monitor capable of displaying at least 1024 x 768 screen resolution
f. Keyboard and mouse

## 2.10 GENERAL NETWORK

A. General

1. The Electronic Theatre Controls Net3 network shall provide data distribution over TCP/IP Ethernet networks. Data shall be layer 3 routable. Systems using proprietary formats or formats other than 10/100/100Mbit wired Ethernet or non-layer 3 routable networks shall not be accepted.

2. Connections shall be made between consoles, face panels, architectural processors, dimmers, Net3 Gateways, and computers over standard Ethernet distribution systems using 100BaseT, 100BaseFL, or greater wiring. All installations shall conform to established Ethernet wiring practice, and installation shall be performed by contractors qualified to do this type of work. All wiring shall be tested at Category 5e or higher for full bandwidth operation to the appropriate IEEE standard.

3. The Lighting Control system must be supplied by a single manufacturer and must have seamless integration over Ethernet between the Entertainment and Architectural lighting control.

B. Capacities

1. The network shall support DMX routing, patching, and prioritization for up to 63,399 universes (32,767,488 DMX addresses). Each address may be input or output from any port on any DMX gateway in the system. DMX input, routing and output shall be specifically supported on the system from multiple sources and locations up to the maximum number of gateways supported by the Ethernet topology.

2. The network shall support multiple network hosts including consoles, gateways, dimming racks, computers, file servers, printers, and architectural control processors with discrete command lines and control. The lighting network shall support multiple venues within a system and discrete systems on the same network.

C. System Configuration and Monitoring

1. Network device configuration shall be via Net3 Gateway Configuration Editor (GCE) software and/or ANSI E1.17 Architecture for Control Networks (ACN).

2. Patch addresses shall support viewing and manipulation via ANSI E1.17 ACN.

   a. The system shall permit complete user flexibility allowing the system operator to patch each DMX input address to any ANSI E1.31 streaming ACN address, and DMX output to span streaming ACN universes.

   b. The lighting system shall support assignment of DMX offsets, truncation of DMX universes, and provide choice of DMX port prioritization.

   c. The lighting system shall support the DD start code extension to ANSI E1.31 which provides priority per address such that multiple control sources can share universes with discrete control per address.

   d. Lighting systems that do not support the above mentioned address patching capabilities shall not be suitable.

3. The system shall allow assignable labels for all network devices to allow easy identification by system users.

4. Each network device shall have a discrete and unique IP address provided automatically by the software. The user may edit this IP address. Systems that do not support automated IP allocation with IP collision avoidance, and systems that do not allow complete reconfiguration of the above mentioned features over ANSI E1.17 ACN shall not be acceptable.

5. All configuration data for each network device shall be held at the device and system operation shall not require continuous on-line operation of the network configuration software.

6. Lighting console operators shall be able to backup the network configurations in the lighting control console. In the event of a network device failure, the operator shall be able to apply the configuration of the failed device to a replacement device of the same type without manually reentering settings. Systems that do not support configuration backup as described above shall not be accepted.

7. Architectural and Entertainment systems connected to the same network shall be capable of arbitrating control over E1.31 Streaming ACN (sACN) level data. The system shall be capable of alternating control of individual address data between architectural and entertainment systems without intervention by the user. The user shall dictate the conditions under which system shall automatically take control. The network shall allow user override of the selected defaults. Systems which require direct user intervention to allocate control of dimmers between architectural and entertainment lighting systems shall not be accepted.

8. The Net3 network shall allow multiple DMX input sources to be prioritized on the same universe as network native sources using E1.31 Streaming ACN prioritization. Multiple DMX inputs may be assigned to the same streaming ACN address (this provides multi-source control for a particular address). Likewise, the system shall support E1.31 prioritization of multiple simultaneous network sources. Systems that cannot prioritize multiple DMX inputs and multiple native network sources on a network shall not be deemed suitable.

9. The lighting network shall allow each DMX input address to be assigned a priority on the network allowing each DMX control level coming into the system to participate in full arbitration. Addresses with the highest priority shall have control, with lower priority addresses being ignored. Addresses assigned the same numeric priority, between 1 and 200, shall respond in highest level takes precedence (HTP) manor. The network shall require a valid DMX signal present at the input to initiate prioritization. Systems that do not allow for prioritized HTP for DMX inputs to the network shall not be allowed.

D. Operational Features

1. Each DMX gateway shall control up to 512 DMX addresses per port, within the confines of up to 63,999 DMX universes (32,747,488 address). The specific DMX data input or output by the gateway shall be configurable by the user.

2. Duplicate outputs of DMX data (DMX splitter) and discrete outputs shall be fully supported.

3. Merging of multiple DMX input sources on a single gateway without gateway with DMX output on the same gateway shall be supported without connection to the network. The gateway shall support assignment of priority to each input source independently

4. File transmission, synchronization and access to software shall be supported.

## 2.11 DMX ETHERNET GATEWAY – ONE PORT

A. General

1. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX-512 data to be encoded, routed over an Ethernet network and decoded back to DMX-512. The unit shall be a Response Mk2 1-port DMX Gateway as provided by ETC, Inc.

2. Gateways shall communicate over Ethernet directly with at least ETC, Inc.'s entertainment and architectural lighting control products and other Ethernet interfaces.

3. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.

4. The gateway shall support multiple protocols including:

   a. ANSI E1.17 Architecture for Control Networks (ACN)
   b. ANSI E1.31 Streaming ACN (sACN)

c. ANSI E1.11 USITT DMX512-A
d. ANSI E1.20 Remote Device Management (RDM)

5. The gateway shall be tested to UL standards and labeled ETL Listed.

6. The gateway shall be RoHS Compliant (lead-free).

7. The gateway shall be CE compliant.

8. The gateway shall have a backlit OLED display and four buttons for identification (soft-labeling), configuration, status reporting and troubleshooting

   a. Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN), or a purpose built software configuration tool.
   b. The OLED display shall show DMX port configuration indication as well as indicate the presence of valid signal.
   c. Gateways that do not indicate port configuration (input/output) and valid data shall not be acceptable.

9. Each gateway shall have LED indicators for Power and network activity

B. DMX Ports

1. The DMX Port shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.

2. The DMX port shall be software-configurable for either input or output functionality.

3. DMX input shall be optically-isolated from the gateway electronics.

4. DMX port shall provide at least 500V isolation to ground and the rest of the electronics

5. The DMX port shall incorporate one DMX512-A Connection

   a. Gateways shall be available with the following connection options: 5-pin male XLR, 5-pin female XLR, or Ethercon RJ-45, for DMX wiring.

6. Network gateways that do not indicate input/ output port configuration or indication of valid data shall not be accepted

C. Processor

1. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 addresses).

2. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 mSec.).

3. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility with 3rd party DMX devices.

D. Mechanical

1. The gateway shall be available in two versions

   a. Wall-mount gateway

      1) The gateway faceplate shall be constructed of injection molded plastic and be formed for use with any standard Decorator style faceplate

      2) A color matched faceplate shall be provided with the gateway

      3) Gateways shall be available in four standard colors

         a) Cream (RAL 9001)
         b) Gray (RAL 7001)
         c) Black (RAL 9004)
         d) Signal White (RAL 9003)

      4) The gateway shall support flush mounting using a standard RACO 1-gang, deep back box or equivalent.

         a) Surface mounting shall also be supported using a manufacturer supplied back box.

   b. Portable gateway

      1) The portable gateway shall include a complete enclosure finished in a black or white fine texture powder coat paint

      2) Wiring connections shall be required for connection to the lighting system

         a) Ethernet connection that supports standard Cat5 patch cables or Ethercon cables. Gateways that do not support the use of Ethercon cables shall not be accepted

         b) DMX input or output connections using is 5-pin XLR or RJ45 Ethercon style connector

         c) Optional low-voltage DC power input connection

E. Power

1. Power for the gateway shall be provided over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 4 watts.

2. An optional 12-24vDC power input shall be available for all wall-mount gateways

3. The gateway electronics shall be electrically isolated from the power supplied over the Catagory5 (or better) cable.

F. Configuration

1. The Gateway must support local or remote configuration.

2. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required for configuration, and shall not be required for normal operation of the system.

3. Each DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes.

4. The specific DMX data input or output by the gateway shall be freely configurable by the user.

5. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.

6. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway.

7. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the configuration PC to be online. Gateways that do not support non-volatile storage of data routing shall not be accepted.

G. Network

1. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.

2. All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.

3. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.

4. ANSI E1.17 Architecture for Control Networks (ACN) and ANSI E1.31 streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.

5. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.

6. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 63,999 universes (32,767,488 addresses) using Streaming ACN (sACN).

   a. Any range of DMX addresses may be selected for each universe.

   b. Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.

   c. Each DMX port shall support its own universe and start address.

7. Gateways shall support built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent channel priorities shall not be accepted.

H. Environmental

1. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).
2. The storage temperature shall be -40° to 70°C (-40° to 158°F).
3. The operating humidity shall be 5% - 95% non-condensing.

I. Accessories

1. Hanging bracket kit shall allow gateway to be mounted using C-Clamp to U-bolt Hardware.
2. ETC Net3 Concert Configuration and monitoring Software

J. System Requirements

1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of Middleton, WI.

## 2.12 POWER DISTRIBUTION – CONNECTOR STRIPS

A. General

1. Connectors shall be available as 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A “U” ground (dual rated “T-slot”); other connectors shall be available as specified

2. Internal wiring shall be sized to circuit ampacity and shall be rated at 125°C and in accordance with NFPA 70, 520.42 and 520.44.

3. Pigtails shall be three-wire type “S” jacketed cable sized for the maximum circuit ampacity

4. Pigtails with 20 amp stage pin connectors shall be terminated using 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket

5. Terminations shall be at one end using feed-through terminals individually labeled with corresponding circuit numbers

   a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire
   b. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire
   c. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire
   d. Terminals that place a screw directly on the wire are not acceptable

6. Connector strips shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings

   a. Connector strips shall have junction brackets on 5’ centers
   b. Brackets shall be 1½” x .188” ASTM A36 steel
   c. Hardware shall be ASTM A307 grade 5

7. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified in the connector strip. Connector strips shall utilize a voltage barrier to accommodate these systems. Low Voltage signals shall enter the connector strip via a strain relief or connector mounted in a separate low voltage terminal box at the specified end of the connector strip. Up to four low voltage cables shall be supported for each connector strip

    a. Connector strips with multiple DMX outputs from the same source shall use DMX pass through assemblies consisting of a 6" panel with the one DMX output connector, one DMX input (Pass Through) connector, one DMX pass through (Bypass) switch, and a label detailing the use of the pass through assembly

    b. The bypass switch shall be used when no DMX devices are present at that location. When activated, the DMX pass through switch shall pass DMX directly through to the next DMX panel on the strip. The pass through switch shall have a mechanical indicator to show the operator that it has or has not been engaged

8. Connector Strips shall be listed by a nationally recognized test lab (NRTL)

9. Equipment grounding shall be in accordance with NFPA 70, 520.81.

B. Physical

1. Connector strips shall be 6.25" H x 3.3" D and fabricated from 18-gauge galvanized steel and finished in black fine-texture powder coat paint

    a. Covers shall be fabricated from 16-gauge galvanized steel

2. Connector strips shall be available in any length specified in increments of 6" and shipped fully wired with all splicing hardware

3. Pigtails and outlets shall be spaced on 18" centers or as otherwise specified

4. Outlets shall be mounted on individual 3" panels

5. No external terminal boxes shall be required for connector strips with 28 or fewer circuits unless otherwise specified

6. Circuits shall be labeled on the connector strip with 2" lettering

    a. Circuit labeling options shall include:

        1) Circuits shall be labeled on the front side of the connector strip with white lettering on black background labels

        2) Circuits shall be labeled on front and back sides of the connector strip with white lettering on black background labels

        3) Circuits shall be labeled on the front side of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels

        4) Circuits shall be labeled on the front and rear sides of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels

5) Circuits shall be labeled on one side of the connector strip using individual circuit cover plates with lettering engraved in the cover and filled with the specified color

6) Circuits shall be labeled using specified labeling per plans and drawings

7. Connector strips shall support optional LED indicators to indicate the presence of power at each local circuit. The indicator shall be red in color and mounted in the connector strip

a. The LED indicator shall be mounted in the lower right corner of the outlet panel
b. The LED indicator shall be mounted in the connector strip trough directly below the outlet panel
c. The LED indicator shall be mounted in the center of the 3" plate directly below the circuit label for pigtail circuits

C. Junction Boxes

1. Gridiron junction boxes shall be available to accommodate "S" type cable wiring into connector strips mounted to non-fixed locations

2. Junction Boxes shall be fabricated from 16-gauge cold rolled steel with 14 gauge end panels. They shall be finished with fine-textured, scratch-resistant, black powder coat paint. Cover(s) shall be 16-gauge cold rolled steel and hinged to allow mounting in any direction

## 2.13 POWER DISTRIBUTION – JUNCTION BOXES

A. General

1. Gridiron junction boxes shall be fabricated from 16-gauge cold rolled steel with 14 gauge end panels.

2. Junction boxes shall be finished with fine-textured, scratch-resistant, black powder coat.

a. Boxes for 30 circuits or less shall be 14"H x 14"W x 4"D
b. Boxes for 31 to 60 circuits shall be 14"H x 28"W x 4"D.

3. Junction boxes shall include mounting brackets and hardware

4. Cover(s) shall be 16-gauge cold rolled steel and hinge to allow installer to orient the hinged door to open in any horizontal direction.

5. Cover(s) shall be attached with machine screws and Tinnerman retainer nuts.

B. Electrical

1. Wiring terminations shall be made using feed through terminals individually labeled with corresponding circuit numbers.

a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire.
b. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire.
c. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire.
d. Terminals that place a screw directly on the wire are not acceptable.

2. Gridiron junction boxes shall be listed by a nationally recognized test lab (nrtl).

3. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified with the gridiron junction box.

    a. Low voltage junction boxes shall attach to gridiron junction boxes to simplify wiring to a discrete device
    b. Low voltage signals shall enter the junction box via a strain relief or connector mounted in a separate low voltage terminal box on the top or bottom of the gridiron junction box.
    c. Up to four low voltage cables shall be supported for each junction box location.

## 2.14 POWER DISTRIBUTION – OUTLET AND PIGTAIL BOXES

A. General

1. Connectors shall be available as 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A "U" ground (dual rated "T-slot"); other connectors shall be available as specified

2. Pigtails shall be three-wire type "S" jacketed cable sized for the maximum circuit ampacity

3. Pigtails with 20 amp stage pin connectors shall be terminated using 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket

4. Terminations for pigtail connectors shall utilize feed- through terminals individually labeled with corresponding circuit numbers

    a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire
    b. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire
    c. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire
    d. Terminals that place a screw directly on the wire are not acceptable

5. Outlet and pigtail boxes shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings

    a. Standard mounting options shall include pipe or wall mounting
    b. Brackets shall be made from ASTM A36 steel
    c. Hardware shall be ASTM A307 grade 5

6. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified in the power distribution box

    a. A voltage barrier shall be used to separate the low voltage wiring for the electrical circuits

7. Power distribution equipment shall be listed by a nationally recognized test lab (NRTL)

B. Physical

1. Outlet and pigtail boxes shall be 6.25” H x 3.3” D and fabricated from 18 gauge galvanized steel and finished in black fine-texture powder coat paint

    a. Covers shall be fabricated from 16-gauge galvanized steel

2. Outlet and pigtail boxes shall be available in any length specified in increments of 3-inches with a maximum length of up to 3-feet

3. Pigtails and outlets shall be spaced on 18” centers or as otherwise specified

4. Outlets shall be mounted on individual 3” panels

5. Circuits shall be labeled with 1.25” lettering

    a. Circuit labeling options shall include:

        1) Circuits shall be labeled on the front side of the connector strip with white lettering on black background labels
        2) Circuits shall be labeled on front and back sides of the connector strip with white lettering on black background labels
        3) Circuits shall be labeled on the front side of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
        4) Circuits shall be labeled on the front and rear sides of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
        5) Circuits shall be labeled on one side of the connector strip using individual circuit cover plates with lettering engraved in the cover and filled with the specified color
        6) Circuits shall be labeled using specified labeling per plans and drawings

6. Outlet and pigtail boxes shall support optional LED indicators to indicate the presence of power at each local circuit. The indicator shall be red in color and mounted in outlet or pigtail box

    a. The LED indicator shall be mounted in the lower right corner of the outlet panel
    b. The LED indicator shall be mounted in the bottom of the outlet or pigtail box directly below the outlet panel
    c. The LED indicator shall be mounted in the cover plate directly below the circuit label for pigtail circuits

## 2.15 POWER DISTRIBUTION - NEMA PLATES

A. General

1. NEMA connector plates shall be available in standard flush mount electrical back boxes from 1-gang up to 5 –gang in size

    a. One outlet shall be provided per gang

2. Connectors shall be available as 20A grounded stage pin, 20A twist lock and 20A “U” ground (dual rated “T-slot”); other connectors shall be available as specified.

3. Terminations shall be made at each connector by the installer contractor.

    a. 20 amp circuits shall use tension clamp terminals listed for 20 – 8 gauge wire.
    b. Terminals that place a screw directly on the wire shall not be acceptable.

4. Connector plates shall mount to RACO #690, #691, #692, #693, #694 (or Equivalent) back boxes using supplied mounting hardware

    a. The back boxes shall be provided by the contractor
    b. Gang-able back boxes shall not be acceptable

5. NEMA connector plates shall be listed by a nationally recognized test lab (nrtl).

B. Physical

1. NEMA connector plates shall be fabricated using .125 aluminum and finished in black fine-texture powder coat paint.

    a. Covers shall be fabricated from 16-gauge galvanized steel

2. Circuits shall be labeled on the connector strip with 9/16” lettering.

    a. Circuit labeling options shall include:

        1) Circuits shall be labeled on the front side of the connector panel with white lettering on black background labels.
        2) Circuits shall be labeled on the front side of the connector panel with engraved lamicoid labels utilizing white lettering on black background labels.
        3) Circuits shall be labeled using specified labeling per plans and drawings

## 2.16 LIGHTING CONSOLE AND ACCESSORIES

A. General

1. The lighting control console shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems. The console shall be the ColorSource 20 AV or ColorSource 40 AV as manufactured by Electronic Theatre Controls, Inc., or equal.

2. The system shall provide control of up to 2,560 networked addresses or up to 1024 local DMX addresses on a maximum of eighty (80) control channels/devices. Addresses may be distributed using DMX512-A (two ports) or via sACN or Art-Net Ethernet-based lighting protocols.

3. A maximum of 999 cues may be contained in non-volatile electronic memory.

4. Twenty (20) or forty (40) faders shall provide access to individual intensity channels, intensity for devices as well as playbacks.

5. Four (4) configurable faders shall provide functionality for controlling audio volume, output of bump buttons, output from the cue list, output from playbacks, or crossfade control.

6. The console shall have one (1) built-in 7" color multi-touch touchscreen. The touchscreen shall provide the primary interface for system configuration, programming show data and multi-parameter control.

7. Six (6) softkey buttons shall be provided, five (5) of which may be configured by the user.

8. Console shall be equipped with an on-board help system.

9. Console shall not require the use of an external monitor for normal use. Optional displays shall be accessible via connection to an external HDMI™ compatible monitor.

10. Console software upgrades shall be made by the user via USB memory stick. Changing internal components shall not be required.

11. The console shall provide a USB port allowing show data to be saved for archival or transfer to other consoles or a personal computer.

12. The console shall be supplied with an onboard 32GB SSD.

13. Systems that do not provide the above capabilities shall not be acceptable.

B. Controls and Playback

1. Patching

a. The console shall provide patching facilities for dimmers and multi-parameter devices via a built in library of fixture definitions. The fixture library shall be updated via software based updates. It shall be possible to create custom fixture definitions using an offline application.

b. The console shall support patching, address setting, and mode changes using Remote Device Management (RDM) on local DMX/RDM ports and on Net3 DMX/RDM Gateway ports.

2. Channel or Playback Faders

a. Twenty (20) or forty (40) proportional, fully overlapping faders shall be provided with 45mm potentiometers and select/bump buttons.

b. The faders shall provide direct manual control of intensity for all channels. Channel levels may be changed at any time by using the individual channel faders. Buttons shall select associated channels for control.

c. Faders shall also control up to ten (10) pages of twenty (20) (or forty (40)) recordable memories or sequences. Memories shall record user-selected channel levels. Sequences shall record user-selected memories or channel levels.

1) With color mixing systems, output of color from fixtures shall appear to be a combination of the active memories in a color space.

3. Programming Tools

a. The console shall provide a 7” color multi-touch touchscreen with six (6) softkeys, as well as touch-based controls. The LCD shall provide system configuration, programming show data and multi-parameter control.

b. Touch-based tools shall include:

1) White and color pickers.

2) Touch-based parameter controls with reference based palettes.

3) Virtual Level/Rate wheel.

4) Virtual keypad for level entry.

5) Customizable channel display using Stage Map. It shall be possible to rearrange the graphical representations for control channels to closely mimic the positions of fixtures in the venue.

6) Effects (intensity, color, shape, and parameter)

a) It shall be possible to assign multiple effects to the same channel and parameters. The playback of those effects shall play levels back relative to the combination of the two effects.

c. Fixture selection shall be made via:

1) Auto fixture selection on fader moves.

2) Pressing the selection button under channel faders.

3) Touching the channel icon in the stage map display on the touch screen.

4) Fixture Tags for Quick Selects

a) Selection of multiple fixture shall be possible through a special controls dock that groups channels together based on the channel tile positions within a pre-defined area in the topographical view for channels.

b) Selection shall be possible through the use of informational tags. Selecting a predefined tag selects all fixtures sharing that same tag. At least two tags may be assigned to any one channel.

c) There shall be at least 27 Quick Select groupings.

d. Two independent channels shall be provided with on/off functionality. Independents shall be patched in a location separate from patch.

e. Audio playback

1) It shall be possible to import sound clips and files to be stored on the console's internal drive.

a) Sound files shall be played back from cues, playback faders as well as selecting the file and playing from the audio tab.

f. Sound to Light

1) The console shall have the ability to analyze sound wave and trigger playbacks 1 through 5 based on base through treble. Playback 6 shall act as a background state.

2) Sound2Light shall apply to the current page of playbacks.

g. Image playback

1) It shall be possible to import image files to be stored on the console's internal drive.

a) Image files shall be played back from cues, playback faders as well as selecting the file and playing from the image tab.

h. Video Toy interactive video effects generator

1) Console shall have a series of predefined video effects that shall be triggered or manipulated though xy positioning of the user's fingers on the on-board multi-touch screen.

a) These effects shall be output via the HDMI port.
b) The video toy engine shall have the ability to be set to automatically trigger the effects based on a set of predefined parameters

i. Amigo Browser based remote.

1) Console shall provide a locally hosted web based control interface accessible by a web browser from a device connected to the same network as the console.

2) Web based interface shall allow for color control, playback control, recording of playbacks and cues.

4. Playback Controls

a. A cue list of up to 999 cues shall be provided. Cues may be made up of channel levels and parameter settings or contain a reference to a recorded memory. Cues shall be editable and shall be able to be individually deleted and inserted.

b. Playback Toy for filtered and timed execution of playbacks.

c. Multiple bump modes (Flash, Solo, SoloChange, Move/GO).

d. Full history rubberbanding for playbacks.

C. Interface Options

1. The AV console shall provide connectors for the following:

a. 12V AC or DC input for external power supply.

b. DMX512-A/RDM output (two (2) 5-pin XLR connectors)

c. USB connection (two (2) type A connectors).

d. RJ45 Ethernet connection (sACN, ArtNet, OSC, Web Interface remote)

e. 3.5mm audio line in and line out connectors

f. HDMI port for console monitor or media playback

1) HDMI connection may be used either for an external monitor to display live show data and onscreen data editing or as an output to a display device (projector, monitor, etc.) for show imagery (pictures, VideoToy).

D. Physical

1. All operator controls and console electronics shall be housed in a single desktop console.

2. Size and weight:

a. Twenty (20) fader console shall be equal to or less than 18.31” (465mm) wide 11” (279mm) deep 2.36” (60mm) high (including controls) and6.9 lbs. (3.13 kg.)
b. Forty (40) fader console shall be equal to or less than 26.31” (668mm) wide 11” (279mm) deep 2.36” (60mm) high (including controls), and 9.55 lbs. (4.33kg).

3. Twenty (20) Fader console shall be able to be mounted into a 19” equipment rack with the use of additional mounting hardware.

4. Console power shall be 12V AC or DC via an external power unit. The power unit shall operate with 90-265VAC line voltage, 50 or 60Hz. Console shall be provided with a universal power supply.

## 2.17 COLOR MIXING OR WHITE-LIGHT LIGHT EMITTING DIODE PROFILE FIXTURE

A. General

1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource Spot, ColorSource Spot Deep Blue or ColorSource Spot Pearl as manufactured by Electronic Theatre Controls, Inc. or approved equal.

2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility

3. The fixture shall be UL 1573 listed for stage and studio use

4. The fixture shall comply with the USITT DMX512-A standard

5. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage

6. ColorSource Spot and ColorSource Spot Deep Blue

    a. The fixture shall have a LM-84 report with a L70 rating of no less than 54,000 hours

        1) Substitutes must provide evidence of minimum L70 rating of no less than 54,000 hours

            a) If no LM-84 report is available, an acceptable alternate is a LM-80 report on all emitters with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report

            b) All tests and reports must be completed by a Nationally Recognized Testing Laboratory

            c) All tests must be conducted to IES standards

7. ColorSource Spot Pearl

    a. The fixture shall have a LM-84 report with a L70 rating of no less than 36,000 hours

        1) Substitutes must provide evidence of minimum L70 rating of no less than 36,000 hours

            a) If no LM-84 report is available, an acceptable alternate is a LM-80 report on all emitters with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report

            b) All tests and reports must be completed by a Nationally Recognized Testing Laboratory

            c) All tests must be conducted to IES standards

B. Physical

1. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits.

2. The following shall be provided:

    a. Lens secured with silicone shock mounts
    b. Shutter assembly shall allow for +/-25□ rotation
    c. 20 gauge stainless steel shutters

d. Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement
e. Sturdy integral die cast gel frame holders with two accessory slots, and a top-mounted, quick release gel frame retainer
f. Rugged steel yoke with two mounting positions allowing 300□+ rotation of the fixture within the yoke
g. Positive locking, hand operated yoke clutch
h. Slot with sliding cover for motorized pattern devices or optional iris

3. The housing shall have a rugged black powder coat finish

a. White or silver/gray powder coat finishes shall be available as color options
b. Other powder coat color options shall be available on request

4. Power supply, cooling and electronics shall be integral to each unit.

5. The unit shall ship with:

a. Theatrical-style hanging yoke as standard
b. 5' cable with Neutrik powerCON™ to choice of connector as standard
c. Gate diffuser
d. A-size pattern holder

6. Available options shall include but not be limited to:

a. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
b. powerCON to powerCON cables for fixture power linking
c. Smooth Wash Diffuser for overlapping beams of light from multiple fixtures

C. Optical

1. The light beam should have a 2-to-1 center-to-edge drop-off ratio

2. The unit shall provide, but not be limited to:

a. Low gate and beam temperature
b. Sharp imaging through a three-plane shutter design

3. The unit shall provide, but not be limited to:

a. 5, 10, 14, 19, 26, 36, 50, 70 and 90 degree field angles
b. High-quality pattern imaging
c. Sharp shutter cuts without halation
d. Shutter warping and burnout in normal use shall be unacceptable
e. Adjustable hard and soft beam edges

4. 19, 26, 36, and 50 degree units shall have optional lens tubes available for precision, high-contrast imaging.

5. Shall work with S4 LED CYC and Fresnel adapters

D. Environmental and Agency Compliance

1. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
2. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use
3. The fixture shall be rated for IP-20 dry location use.

E. Thermal

1. Fixture shall be equipped with a cooling fan.

2. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 54,000 hours of use for color mixing versions and 36,000 hours for Pearl

    a. Thermal management shall include multiple temperature sensors within the housing to include:

        1) LED array circuit board temperatures
        2) Fixture ambient internal temperature

3. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

F. Electrical

1. The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply

2. The fixture shall support power in and thru operation

    a. Power in shall be via Neutrik® powerCON™ input connector
    b. Power thru shall be via Neutrik ® powerCON™ output connector
    c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker

3. The fixture requires power from a non-dim source

4. Fixtures shall have droop compensation to prevent thermal shift of color or intensity

5. Power supply outputs shall have self-resetting current-limiting protection

6. Power supply shall have power factor correction

G. LED Emitters

1. The fixture shall contain a minimum of four different LED colors to provide color characteristics or two color temperature white LEDs for the Pearl products, as described in the Color Section below

2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.

    a. Fixture shall utilize Luxeon® Rebel™ LED emitters

3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.

4. LED emitters should be rated for nominal 54,000-hour L70 rating for color mixing versions and 36,000-hour L70 rating for Pearl variant

5. LED system shall comply with all relevant patents

H. Calibration

1. Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins

    a. Calibration data shall be stored on the control card as a permanent part of on-board operating system
    b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
    c. Fixtures not offering LED calibration shall not be acceptable

I. Color

1. The fixture shall utilize an minimum of 60 LED emitters

    a. These emitters shall be made up of Red, Green, Blue and Lime for ColorSource
    b. These emitters shall be made up of Red, Green, Indigo and Lime for ColorSource Deep Blue
    c. These emitters shall be made up of 2700 K and 6500 K for ColorSource Pearl

J. Dimming

1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.

2. The fixture shall utilize an Incandescent dimming curve

3. Dimming curve shall be optimized for smooth dimming over longer timed fades.

4. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)

5. LED control shall be compatible with broadcast equipment in the following ways:

    a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    b. PWM shall be capable of being set via RDM to 25,000hz

K. Control and User interface

1. The fixture shall be USITT DMX512-A compatible via In and Thru 5-pin XLR connectors or RJ45 connectors

2. The fixture shall be compatible with the ANSI RDM E1.20 standard

   a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
   b. Temperature sensors within the luminaire shall be viewable in real time via RDM
   c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible

3. The fixture shall be equipped with a 7-segment display

4. The fixture shall be equipped with a three-button user-interface

5. A variable-rate strobe channel shall be provided

6. The fixture shall offer stand-alone functionality eliminating the need for a console

   a. Fixture shall ship with 12 preset colors or color temperatures accessible as a stand-alone feature

   b. Fixture shall ship with 5 sequences accessible as a stand-alone feature

   c. Each color and sequence can be modified by the end user via RDM

   d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture

      1) Up to 32 fixtures may be linked

   e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming

   f. Fixtures without stand-alone operation features described above shall not be acceptable.

## 2.18 COLOR MIXING LIGHTING EMITTING DIODE WASH FIXTURE

A. General

1. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource PAR, ColorSource PAR Deep Blue or ColorSource PAR Pearl as manufactured by Electronic Theatre Controls, Inc. or approved equal.

2. All LED fixtures shall be provided by a single manufacturer to ensure compatibility

3. The fixture shall be UL 1573 listed for stage and studio use

4. The fixture shall comply with the USITT DMX512-A standard

5. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage

B. ColorSource PAR and ColorSource PAR Deep Blue

1. The fixture shall have a LM-84 report with a L70 rating of no less than 55,000 hours

a. Substitutes must provide evidence of minimum L70 rating of no less than 55,000 hours

1) If no LM-84 report is available, an acceptable alternate is a LM-80 report on all emitters with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report

2) All tests and reports must be completed by a Nationally Recognized Testing Laboratory

3) All tests must be conducted to IES standards

C. ColorSource PAR Pearl

1. All LED emitters must have a L70 rating of no less than 20,000 hours

a. Substitutes must provide evidence of minimum L70 rating of no less than 60,000 hours via a LM-80 report on all emitters

1) LM-80 report must be provided with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report

2) All tests and reports must be completed by a Nationally Recognized Testing Laboratory

3) All tests must be conducted to IES standards

D. Physical

1. The fixture shall be contained in a rugged all-metal die-cast housing, free of burrs and pits.

2. The housing shall have a rugged black powdercoat finish

a. White or silver/gray powdercoat finishes shall be available as color options
b. Other powdercoat color options shall be available on request

3. Power supply, cooling and electronics shall be integral to each unit.

4. Fixture housing shall provide two easy-access slots for secondary lenses and other accessories

a. Slots shall be equipped with locking retaining clip

5. The unit shall ship with:

    a. Theatrical-style hanging yoke as standard
    b. 5’ power lead with Edison connector as standard

6. Available options shall include but not be limited to:

    a. Floor stand conversion Kit

    b. Bare-end, Stage-Pin or Twist-lock type-equipped power leads

    c. powerCON to powerCON cables for fixture power linking

    d. Multiple secondary lens options to include multiple angles in the following patterns:

        1) Linear
        2) Round
        3) Oblong

7. Light output shall be via a round aperture

    a. Aperture and accessory slots shall accommodate standard 7.5” accessories such as used in other similar-sized fixtures

    b. Accessories available as options shall include but not be limited to:

        1) Gel/diffusion frames
        2) Top hats
        3) Barndoors
        4) Egg crate louvers
        5) Concentric ring louvers
        6) Multiple secondary lensing options

E. Environmental and Agency Compliance

1. The fixture shall be UL and cUL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
2. The fixture shall be UL LISTED to the UL1573 standard for stage and studio use
3. The fixture shall be rated for IP-20 dry location use.

F. Thermal

1. The fixture shall be cooled with a variable speed fan.

2. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 20,000 hours of use for color mixing versions and 36,000 hours of use for Pearl variety

    a. Thermal management shall include multiple temperature sensors within the housing to include:

        1) The LED array

2) The control board

3. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

G. Electrical

1. The fixture shall be equipped with 100V to 240V 50/60 Hz internal power supply

2. The fixture shall support power in and thru operation

a. Power in shall be via Neutrik® powerCON™ input connector
b. Power thru shall be via Neutrik ® powerCON ™ output connector
c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker

3. The fixture requires power from non-dim source

4. Power supply outputs shall have self-resetting current limiting protection

5. Power supply shall have power factor correction

H. LED Emitters

1. The fixture shall contain 4 different LED colors to provide color characteristics or two color temperature white LEDs for the Pearl products, as described in Section H below.

2. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.

a. Fixture shall utilize Luxeon® Z™ LED emitters

3. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.

4. LED emitters should be rated for nominal 20,000-hour L70 rating for color mixing versions and 36,000-hour L70 rating for Pearl variant

5. LED system shall comply with all relevant patents

I. Calibrated

1. Fixture shall be calibrated at factory for achieve consistent color between fixtures built at different times and/or from different LED lots or bins

a. Calibration data shall be stored in the fixture as a permanent part of on-board operating system
b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
c. Fixtures not offering LED calibration shall not be acceptable

J. Color

1. The fixture shall utilize an minimum of 40 LED emitters

    a. These emitters shall be made up of Red, Green, Blue and Lime for ColorSource
    b. These emitters shall be made up of Red, Green, Indigo and Lime for ColorSource Deep Blue
    c. These emitters shall be made up of 2700 K and 6500 K for ColorSource Pearl

K. Dimming

1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.

2. The dimming curve shall be optimized for smooth dimming over longer timed fades.

3. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)

4. LED control shall be compatible with broadcast equipment in the following ways:

    a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    b. PWM rates shall be adjustable by the user via RDM to avoid any visible interference to video cameras and related equipment

L. Control and User Interface

1. The fixture shall be USITT DMX512-A compatible via **In** and **Thru** 5-pin XLR connectors

2. The fixture shall be compatible with the ANSI RDM E1.20 standard

    a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible

3. The fixture shall be equipped with a 7-segment display for easy-to-read status and control

4. The fixture shall be equipped with a three-button user-interface

5. The fixture shall offer RGB control

6. The fixture shall operate in Regulated mode for droop compensation

7. The fixture shall offer stand-alone functionality eliminating the need for a console

    a. Fixture shall ship with 12 preset colors accessible as a stand-alone feature

    b. Fixture shall ship with 5 Sequences accessible as a stand-alone feature

    c. Each color and sequence can be modified by the end user

d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture.

1) Up to 32 fixtures may be linked.

e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming

f. Fixtures without stand-alone operation features described in a, b, c, d, and e shall not be acceptable.

## 2.19 THEATRICAL LIGHTING BILL OF MATERIALS

A. Following is a detailed list of materials with quantities for specific line items listed in part 2 above.

| Qty. | Model | Part Number | Description |
|---|---|---|---|
| **System: Unison Paradigm Unison Paradigm Control and Accessories** | | | |
| 1 | P-ACP3 | 7180A1029 | Paradigm Architectural Control Processor |
| 1 | P-SPM-E | 7182A1701 | Paradigm Station Power Module - supports 63 stations and (1) 500m wire segment |
| 1 | ERN2-RM-120 | 7180A1013 | ERn2 Rack Mount 120V Enclosure |
| **Unison Paradigm and Heritage Stations** | | | |
| 2 | UH10001-11 | 7181A2201-1A | Cream 1-gang faceplate assembly to accept the following: 1 - On/Off Select Switch |
| 2 | UH10001 | 7181B2004 | 1-gang, 1-button electronics assembly |
| 2 | P-TS7-E-1 | 7184A1541-1 | P-TS7-E Paradigm 7" Wall-mount Ethernet Touchscreen - Cream |
| **Unison Locking Covers, Remotes and Accessories** | | | |
| 2 | P-LCD-SBB | 7184A1503 | PLCD, PARADIGM SRFC MNT TOUCHSCREEN BBOX |
| **System: Sensor IQ Relay Panel** | | | |
| 1 | IQ48 | 7131A1061 | Sensor IQ, 48 pole, 400A / 120V, 3P, breaker panel including control processor |
| 48 | IQ SM B20 | CB852-2 | Sensor IQ circuit breaker w/relay, 20A, 1P, 120V |
| 1 | IQ DOOR 120-48S | 7131A1551 | Sensor IQ, 48 pole, 120V, surface mount door |
| 1 | IQ-MB200A22K | 7131K1022 | 120V, 200A, 25KA SCCR, 3P, top feed main breaker |
| **System: EMERGENCY ACCESSORIES** | | | |
| 1 | EBDK | 7180A1200 | Emergency Bypass Detection Kit |
| 1 | DEBC-6 | 7180A1226 | Six output DMX Emergency Bypass Controller |
| 1 | QO310 | PJCB1006 | 120V Three Phase Circuit Breaker for Sense Feed -- (1) Square D QO310 3-Phase, 10A circuit breaker |

| | | | |
|---|---|---|---|
| 1 | QO403L60NS | PJCB1007 | Square D QO403L60NS wall-mountable circuit breaker enclosure |
| **NETWORK EQUIPMENT RACK** | | | |
| 1 | 19" RACK | CPN-RACK | Black 19" DWR Equipment Rack |
| 1 | CBS350-24P-4G-NA | CPN-SWITCH | CBS350-24P-4G-NA - Cisco Business 350 Switch |
| 1 | PATCH PANEL 24X | 2100A2008 | 2U 19" rack-mount patch panel with 24 open slots |
| 1 | MAP BR1 | SGE1061 | MAP BR1 - 1U Brush Grommet Panel |
| 1 | SWITCH RACK KIT | CPN | NETWORK SWITCH RACK ACCESSORY KIT |
| 1 | MAP 1000R | PJPS1012 | Uninterruptible Power Supply |
| 1 | PWPP RM P4 | SGN1406-M | PWPP RM P4 TERM REAR - Pathway 4 Port Rack-Mount Gateway Terminal |
| 1 | WAP | SGN1282-M | WAP - Cisco Wireless Access Point - 802.11ac/n - Internal antennas - PoE powered |
| **CONTROL CONSOLE** | | | |
| 1 | ELEMENT 2 6K | 4331A1012-US | Element 2 Console, 6,144 Outputs |
| 2 | LCD MTMON 22 | M250 | 22 LCD Multi-touch Monitor (Industrial Grade) |
| 1 | CD25-Net | N4028 | 25' network control cable twisted pair, RJ45 |
| 1 | CD25-DMX | 1085A1002 | 25' DMX control cable |
| 1 | ETCPAD | 4250A1122 | ETCpad - Portable Access Device |
| **CONTROL PLUG IN STATIONS** | | | |
| 1 | ECPN-NET/NET/NET | CPN | ECPB; NET / NET / NET Plug-in station (3 gang) |
| 1 | ECPB NET/AC | 1094A1056 | ECPB; NET / AC Plug-in station (2 gang) |
| 1 | ECPB NET/NET | 1094A1057 | ECPB; NET / NET Plug-in station (2 gang) |
| 1 | ECPB NET | 1094A1045 | ECPB; NET Plug-in station (1 gang) |
| **ELECTRICAL DISTRIBUTION DEVICES: STAGE ELECTRICS** | | | |
| **STAGE ELECTRICS** | | | |
| 4 | 9940 | CPN | 9940-(18AO/6)(1R2GO)-X-XX - Connector strip 40'-0" long with:<br>18 - Panel mount 20A Edison (5-20R) connect-ors wired on 6 - 20A circuits<br>1 – Two Port Gateway<br>X – hanging brackets as required |
| 4 | 9710 | 7099A1710 | 9710 - Gridiron Junction Box with mounting hard-ware and terminals for (10) 20A circuits |
| 4 | NET/1(XLR) | 7099A1703-1 | NET/1(XLR) - NET Gridiron Junction Box with 1 connectorized RJ-45 (568B) Network output |
| 4 | CPN | CPN | 12/xx SO - 12 gauge, xx conductor SO Multi-cable - as required |
| 4 | PROPLEX NET | CPN | PROPLEX NET - NET Data Cable - as required |
| 4 | CPN | CPN | Traditional Cable Management single-purchase cable cradle |
| 4 | KELLEMS | CPN | KELLEMS - Dusttight Kellems grip for use with Multi-SO cable |

| | | | |
|---|---|---|---|
| **FOH ELECTRICS** | | | |
| 2 | 9100 | CPN | 9100 Series - Surface Mount Outlet Box with:<br>6 – panel mount 20A Edison (5-20R) connectors wired on 3 - 20A circuits<br>1 – Two Port Gateway with voltage barrier |
| 2 | UBOLTKIT | 7099A1050 | UBOLTKIT - U-Bolt Pipe-mounting Assembly (1 pair) |
| 2 | 9705 | 7099A1705 | 9705 - Gridiron Junction Box with mounting hard-ware and terminals for (5) 20A circuits |
| 2 | NET/1(XLR) | 7099A1703-1 | NET/1(XLR) - NET Gridiron Junction Box with 1 connectorized RJ-45 (568B) Network output |
| 2 | CPN | CPN | 12/xx SO - 12 gauge, xx conductor SO Multi-cable - as required |
| 2 | PROPLEX NET | CPN | PROPLEX NET - NET Data Cable - as required |
| 2 | CPN | CPN | Traditional Cable Management single-purchase cable cradle |
| 2 | KELLEMS | CPN | KELLEMS - Dusttight Kellems grip for use with Multi-SO cable |
| **TORM ELECTRICS** | | | |
| 4 | 9906 | CPN | 9906-(4AO]/2)(1R1GO)-X-XX - Connector strip 6'-0" long with:<br>4 – panel mount 20A Edison (5-20R) con-nectors wired on 2 - 20A circuits<br>1 – Two Port Gateway with voltage barrier<br>3 – hanging brackets |
| **WALL BOX PLUG IN STATIONS** | | | |
| 2 | 9100 | CPN | 9100 Series - Surface Mount Outlet Box with:<br>2 – panel mount 20A Edison (5-20R) connectors wired on 1 - 20A circuits<br>1 – One Port Gateway with voltage barrier |
| **THEATRICAL FIXTURES AND ACCESSORIES** | | | |
| 30 | CSSPOTVMVS | 7423A1011 | ColorSource Spot V ETL with Shutter Barrel with Multiverse - Black |
| 30 | T1PA-A | 2500B7029-A | TRUE1 female to Edison male, UL 1573, 6 ft/2 m |
| 15 | 41530LT | 7060A2030-K | 15-30° Zoom Lens Tube with Color Frame |
| 15 | 42550LT | 7060A2032-K | 25-50° Zoom Lens Tube with Color Frame |
| 30 | 400CC | 7060A2009 | C-Clamp, black |
| 30 | 400SC | 7060A1022 | Safety Cable (30 in / 762 mm), black |
| 30 | DMX-10' | | 10' DMX 5Pin Jumper Cable |
| 30 | T1PJ-10 | 2500B7031 | TRUE1 female to TRUE1 male fixture power jumper, UL rated, 10 ft/3 m |
| 36 | CSPAR | 7412A1005 | ColorSource PAR, XLR, black |
| 36 | DPA-A | 7410B7037-A | powerCON female to Edison, UL 1573, 5 ft/1.5 m (replacement) |
| 36 | SELRW-7.5 | | D40/CSPAR Wide Round Diffuser in Frame, black |
| 36 | 400CC | 7060A2009 | C-Clamp, black |
| 36 | 400SC | 7060A1022 | Safety Cable (30 in / 762 mm), black |
| 36 | DMX-10' | | 10' DMX 5Pin Jumper Cable |

| | | | |
|---|---|---|---|
| 36 | DPJ-10 | 7410B7010 | powerCON female to powerCON male fixture power jumper, 10 ft/3.0 m |
| 16 | CSSPOTJR2550 | 7416A1001 | ColorSource Spot jr, Original, black, ETL |
| 16 | DPA-A | 7410B7037-A | powerCON female to Edison, UL 1573, 5 ft/1.5 m (replacement) |
| 16 | 400CC | 7060A2009 | C-Clamp, black |
| 16 | 400SC | 7060A1022 | Safety Cable (30 in / 762 mm), black |
| 16 | DMX-10' | | 10' DMX 5Pin Jumper Cable |
| 16 | DPJ-10 | 7410B7010 | powerCON female to powerCON male fixture power jumper, 10 ft/3.0 m |
| 10 | MXLR5TERM | SGE1507 | DMX Terminator, 5-pin XLR male |
| 2 | | | CANTO ASTRO600 FOLLOWSPOTS |
| **SERVICES** | | | |
| | | •Factory Documentation Pack<br>•Factory Commissioning/Training<br>•Factory LightDesigner Config. | |
| **NOTES** | | | |

PART 3 - EXECUTION

3.1 INSTALLATION

A. It is the intent of these specifications and plans to include everything required for proper and complete installation and operation of the dimming system, even though every item may not be specifically mentioned.

B. Shall be responsible for field measurements and coordinating physical size of all equipment with the architectural requirements of the spaces into which they are to be installed.

C. Install all lighting control and dimming equipment in accordance with manufacturers approved shop drawings.

D. All branch load circuits shall be live tested before connecting the loads to the dimmer system load terminals.

E. Theatre System Integrator shall provide all low voltage control terminations.

3.2 MANUFACTURER'S SERVICES

A. Upon completion of the installation, including testing of load circuits, the contractor shall notify the dimming system manufacturer that the system is available for formal checkout.

B. Notification shall be provided in writing, two weeks prior to the time that factory-trained personnel are needed on the job site.

C. No power is to be applied to the dimming system unless specifically authorized by written instructions from the manufacturer.

D. The purchaser shall be liable for any return visits by the factory engineer as a result of incomplete or incorrect wiring.

E. Upon completion of the formal check-out, the factory engineer shall demonstrate operation and maintenance of the system to the owner's representatives. Training shall not exceed four working hours. Additional training shall be available upon request.

## 3.3 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two years from date of delivery.
B. Warranty shall cover repair or replacement of such parts determined defective upon inspection.

END OF SECTION 26 55 61

# SECTION 27 15 00 - COMMUNICATIONS HORIZONTAL CABLING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. UTP cabling.
2. Cable connecting hardware, patch panels, and cross-connects.
3. Telecommunications outlet/connectors.
4. Cabling system identification products.
5. Cable management system.

### 1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.
B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
D. EMI: Electromagnetic interference.
E. IDC: Insulation displacement connector.
F. LAN: Local area network.
G. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
I. RCDD: Registered Communications Distribution Designer.
J. UTP: Unshielded twisted pair.

### 1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

## 1.5 ACTION SUBMITTALS

A. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

3. Cabling administration drawings and printouts.

4. Wiring diagrams to show typical wiring schematics, including the following:

   a. Cross-connects.
   b. Patch panels.
   c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
B. Source quality-control reports.
C. Field quality-control reports.

## 1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

B. 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.

## 1.8 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.

2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

## 1.9 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test each pair of UTP cable for open and short circuits.

# PART 2 - PRODUCTS

## 2.1 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

## 2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing 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.

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. Grounding: Comply with J-STD-607-A.

## 2.3 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

## 2.4 UTP CABLE

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. ADC.
2. Belden Inc.
3. Berk-Tek; a Nexans company.
4. CommScope, Inc.
5. Draka Cableteq USA.
6. Genesis Cable Products; Honeywell International, Inc.
7. Mohawk; a division of Belden Networking, Inc.
8. Superior Essex Inc.
9. SYSTIMAX Solutions; a CommScope, Inc. brand.
10. 3M Communication Markets Division.
11. Tyco Electronics Corporation; AMP Products.

C. Description: Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568-C.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

## 2.5 UTP CABLE HARDWARE

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Dynacom Inc.
5. Hubbell Premise Wiring.
6. Leviton Commercial Networks Division.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Co. (The).
10. Tyco Electronics Corporation; AMP Products.

C. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

D. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable indicated.

G. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

H. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

## 2.6 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.

B. Workstation Outlets: Four-port-connector assemblies mounted in multigang faceplate.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."

2. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."

3. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.

a. Flush mounting jacks, positioning the cord at a 45-degree angle.

4. Legend: Factory labeled by silk-screening or engraving for stainless steel faceplates.

5. Legend: Machine printed, in the field, using adhesive-tape label.

6. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

## 2.7 GROUNDING

A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
B. Comply with J-STD-607-A.

## 2.8 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. Comply with requirements in Section 260553 "Identification for Electrical Systems."

## 2.9 CABLE MANAGEMENT SYSTEM

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. iTRACS Corporation, Inc.
2. TelSoft Solutions.

C. Description: Computer-based cable management system, with integrated database and graphic capabilities.

D. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.

E. Information shall be presented in database view, schematic plans, or technical drawings.

1. AutoCAD drawing software shall be used as drawing and schematic plans software.

F. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

## 2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.

E. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

F. Cable will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

# PART 3 - EXECUTION

## 3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

## 3.2 WIRING METHODS

A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters. Conceal pathways and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements in Section 270528 "Pathways for Communications Systems."
3. Comply with requirements in Section 270536 "Cable Trays for Communications Systems."

B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures:

1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Install lacing bars and distribution spools.
3. Install conductors parallel with or at right angles to sides and back of enclosure.

## 3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Install 110-style IDC termination hardware unless otherwise indicated.

4. MUTOA shall not be used as a cross-connect point.

5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:

   a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
   b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

12. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

G. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches.

H. Group connecting hardware for cables into separate logical fields.

I. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

## 3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."
B. Comply with TIA-569-B, Annex A, "Firestopping."
C. Comply with BICSI TDMM, "Firestopping Systems" Article.

## 3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

## 3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Section 099100 "Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.

3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.

4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.

b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

D. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

## 3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.

2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. UTP Performance Tests:

    a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:

        1) Wire map.
        2) Length (physical vs. electrical, and length requirements).
        3) Insertion loss.
        4) Near-end crosstalk (NEXT) loss.
        5) Power sum near-end crosstalk (PSNEXT) loss.
        6) Equal-level far-end crosstalk (ELFEXT).
        7) Power sum equal-level far-end crosstalk (PSELFEXT).
        8) Return loss.
        9) Propagation delay.
        10) Delay skew.

6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

    a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

    b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 27 15 00

# SECTION 28 31 11 - DIGITAL, ADDRESSABLE FIRE-ALARM AND VOICE NOTIFICATION SYSTEM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Scope:

1. At Walter Panas High School and Lakeland High School relocate and/or extend existing fire alarm system as required to incorporate fire alarm work shown on the floor plans. Provide programming for all new devices. All fire alarm work shall be compatible with the existing fire alarm system.

2. At Copper Beach Middle School, extend existing fire alarm system as required to incorporate fire alarm work shown on the floor plans. Provide programming for all new devices. All fire alarm work shall be compatible with the existing fire alarm system.

B. Section Includes:

1. Manual fire-alarm boxes.
2. System smoke detectors.
3. Heat detectors.
4. Notification appliances.
5. Magnetic door holders.
6. Addressable interface devices.

### 1.3 REFERENCES

A. Comply with New York State Uniform Fire Prevention & Building Code.

B. Comply with U.S. Department of Justice – American Disabilities Act.

C. Acoustical Society of America (ASA)

1. ASA S3.2 Method for Measuring the Intelligibility of Speech Over Communications Systems.

D. National Fire Protection Association Standards:

1. NFPA 70 - National Electrical Code.
2. NFPA 72 - National Fire Alarm Code.
3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

E. Provide system and components listed by Underwriters Laboratories Inc. (UL) for use in fire protective signaling system under following standards as applicable:

1. UL 864 - UOJZ, APOU Control Units for Fire Protective Signaling Systems.
2. UL 268 - Smoke Detectors for Fire Protective Signaling Systems.
3. UL 268A - Smoke Detectors for Duct Applications.
4. UL 521 - Heat Detectors for Fire Protective Signaling Systems.
5. UL 228 - Door Holders for Fire Protective Signaling Systems.
6. UL 464 - Audible Signaling Appliances.
7. UL 1971 - Visual Signaling Appliances.
8. UL 38 - Manually Activated Signaling Boxes.
9. UL 1481 - Power Supplies for Fire Protective Signaling Systems.

## 1.4 DEFINITIONS

A. LED: Light-emitting diode.
B. NICET: National Institute for Certification in Engineering Technologies.
C. LOC: Local Operating Console.
D. VNS: Voice Notification System.

## 1.5 SYSTEM DESCRIPTION

A. Non-coded, UL-certified addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

B. Provide equipment, materials, installation, inspection, and testing in strict accordance with the required and advisory provisions of NFPA 70, NFPA 72, except as modified herein. The system layout on the drawings shows the intent of coverage and are shown in suggested locations. Submit plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, wire counts, circuit identification in each conduit, and circuit layouts for all floors. Drawings shall comply with the requirements of NFPA 170. Final quantity, system layout, and coordination are the responsibility of the Contractor

C. Provide Common Intelligibility Scale (CIS) and sound pressure level calculations with the shop drawing submittal to confirm that intelligibility requirements will be met. CIS calculations shall be done with computer software intended for that purpose.

## 1.6 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control panel and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the panel will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the panel will be fully operational after the seismic event."

## 1.7 SUBMITTALS

A. General Submittal Requirements:

1. Shop Drawings shall be prepared by persons with the following qualifications:

   a. Trained and certified by manufacturer in fire-alarm system design.
   b. NICET-certified fire-alarm technician, Level IV minimum.

B. Product Data: Submit manufacturer′s documentation for all components of proposed fire alarm system required to demonstrate compliance with specified requirements, including (but not limited to) type, size rating, style, catalog number, manufacturer name, photographs, and catalog data sheet for each component.

C. Shop Drawings: 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 with the system operating on battery power, with battery voltage to the system at 20 volts.

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 complete one-line riser diagrams showing all equipment locations and sizes, and point-by-point wiring diagram with type and number of all conductors.

7. Submit detailed drawing of FAVN Panel(s) including all module/component locations and panel point-to-point wiring diagrams including all field circuit termination points.

8. Submit floor plan layout of Graphic Display Panel indicating building zones, room numbers, and “You Are Here” location. Orient building floor plan on graphic to the location of person viewing the installed Graphic Display Panel, i.e. the direction the viewer is facing shall be toward the top of the graphic display.

D. Qualification Data:

1. Supervisor:

a. NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level 4 Fire Alarm Technician shall supervise the installation of the fire alarm system/voice notification system.A Fire Alarm Technician with a minimum of 8 years of experience shall perform/supervise the installation of the fire alarm/voice notification system. The Fire Alarm technicians supervising the installation of equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.Technician:

b. NICET Level III Fire Alarm Technicians with a minimum of four years of experience utilized to install and terminate fire alarm/voice notification devices, cabinets and panels. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

2. Installer:

a. Fire Alarm installer with a minimum of two years of experience utilized to assist in the installation of fire alarm/voice notification devices, cabinets and panels NICET Level II technician to assist in the installation of fire alarm/voice notification devices, cabinets and panels. An electrician shall be allowed to install wire, cable, conduit and backboxes for the fire alarm system/voice notification system. The Fire Alarm installer shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

3. Test Personnel:

a. Fire Alarm Technicians with a minimum of eight years of experience (NICET Level III) utilized to test and certify the installation of the fire alarm/voice notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

4. Manufacturer's Representative:

a. The fire alarm and voice notification equipment manufacturer's representative shall be present for the connection of wiring to the control panel. The Manufacturer's Representative shall be an employee of the manufacturer with necessary technical training (NICET Level III or[, IV)on the system being installed.

5. Manufacturer:

a. Components shall be of current design and shall be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as otherwise or additionally specified herein.

E. Regulatory Requirements

1. Requirements for Fire Protection Service:

   a. Equipment and material shall have been tested by UL and listed in UL Fire Prot Dir or approved by FM and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, they shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement. All listings or approval by testing laboratories shall be from an existing ANSI or UL published standard.

2. Fire Alarm/Voice Notification System:

   a. Furnish equipment that is compatible and is UL listed, FM approved, or listed by a nationally recognized testing laboratory for the intended use. All listings by testing laboratories shall be from an existing ANSI or UL published standard. Submit a unique identifier for each device, including the control panel and initiating and indicating devices, with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information. Include the NFPA 72 Record of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

3. Fire alarm Testing Services or Laboratories:

   a. Construct fire alarm and fire detection equipment in accordance with UL Fire Protection Dir, UL Electrical Construction, or FM APP GUIDE.

4. Contractor performing fire alarm system work shall be a licensed fire alarm contractor. Contractor shall provide Fire Alarm Installation Certification with fire alarm system submittal.

F. Seismic Qualification Certificates: For fire-alarm control panel, 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 Panel: 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 fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," 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:

   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 fire-alarm control panel.

7. Copy of NFPA 25.

## 1.8 QUALITY ASSURANCE

A. Source Limitations for Fire-Alarm/Voice Notification System and Components: Obtain fire-alarm/Voice Notification system 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. NFPA Certification: Obtain certification according to NFPA 72 by a Nationally Recognized Testing Laboratory (NRTL).

## 1.9 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

   1. Coordinate and comply with the requirements of the local Fire Marshall, or Authority Having Jurisdiction, concerning the fire alarm system shutdown plans, procedures, and fire watch plans that will be implemented for system interruptions during construction. All existing fire alarm devices shall remain active until new cabling and devices are installed. Temporary interruptions are allowed while work is being done on the system. Work shall be coordinated so that system is fully functional at the end of the workday. If system is not fully functional at end of workday, Contractor shall provide personnel for fire watch as required by local Fire Marshall and shall be responsible for all associated costs.

   2. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of fire-alarm service.

3. Do not proceed with interruption of fire-alarm service without Construction Manager and Owner's written permission.

## 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 5 percent of amount installed, but no fewer than 2 units.
2. Strobe Units: Quantity equal to 5 percent of amount installed, but no fewer than 2 units.
3. Smoke Detectors and Heat Detectors: Quantity equal to 5 percent of amount of each type installed, but no fewer than 2 units of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 2 units of each type.
5. Keys and Tools: One extra set for access to locked and tamper proofed components.
6. Audible and Visual Notification Appliances: Quantity equal to 5 percent of amount installed, but no fewer than 2 units.
7. Fuses: Five of each type installed in the system.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

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. NOTIFIER; a Honeywell company.
2. Siemens Building Technologies, Inc.; Fire Safety Division.
3. SimplexGrinnell LP; a Tyco International company.

## 2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Verified automatic alarm operation of smoke detectors
6. CO detectors.
7. Automatic sprinkler system water flow.
8. Fire-extinguishing system operation.
9. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm/voice notification appliances.
2. Identify alarm at fire-alarm control panel and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Release fire and smoke doors held open by magnetic door holders.
5. Shut down heating, ventilating, and air-conditioning equipment.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Recall elevators to primary or alternate recall floors.
8. Activate emergency shutoffs for gas and fuel supplies.
9. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Elevator shunt-trip supervision.

D. System trouble signal initiation shall be by one 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/voice notification control panel.
4. Ground or a single break in fire-alarm control panel internal circuits.
5. Abnormal ac voltage at fire-alarm control panel.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm/voice notification control panel or annunciator.
9. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.

E. System Trouble and Supervisory Signal Actions: Annunciate at fire-alarm/voice notification control panel and remote annunciators.

## 2.3 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 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 panel.

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 at locations where indicated.

## 2.4 SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.

2. Detectors shall be two-wire type.

3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control panel.

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.

7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control panel for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control panel.

   a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control panel for 15 or 20 deg F (8 or 11 deg C) per minute.
   b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control panel to operate at 135 or 155 deg F (57 or 68 deg C).
   c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control panel and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control panel, having the designated access level, shall be able to manually access the following for each detector:

   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control panel and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control panel, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.
b. Device type.
c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

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. Addressable Interface Device Fan Shutdown Relay: Rated to interrupt fan motor-control circuit.

## 2.5 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 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) 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 panel.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).

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 panel.

## 2.6 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.

B. Test button simulates an alarm condition.

## 2.7 ADDRESSABLE INTERFACE DEVICES

A. Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Microelectronic relay module: Relay shall have form C dry contacts. NRTL listed for use in providing a system address for providing a signal to:

1. Air handling units to initiate fan shutdown.
2. Elevator controller to initiate elevator recall.
3. Circuit-breaker shunt trip for power shutdown.

## 2.8 NOTIFICATION APPLIANCES

A. Fire Alarm/Voice Notification Speakers

1. Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Surface mounted audible appliances shall be factory painted red.

a. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Tap settings shall include taps of 1/8, 1/4, 1/2, 1, and 2 watts. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 150 Hz to 10,000 Hz, and shall have a sealed back construction. Speakers shall be capable of installation on standard 100 mm square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single wall or ceiling mounted unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FAVN panel.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 1.519 mm (16 gauge) or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

c. Speakers shall utilize screw terminals for termination of all field wiring.

B. Visual Notification Appliances

1. Visual notification appliances shall conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). The lens of the fire alarm strobe shall be located such that the entire lens is located not less than 80 inches and not more than 96 inches above the finished floor. Fire Alarm Notification Appliances shall have clear high intensity optic lens, xenon flash tubes, and be marked "Fire" in red letters. The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate shall be 1 flash per second and a minimum of 15 candela, Strobe shall be surface mounted to masonry walls and semi-flush mounted to walls constructed of gypsum wall board. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices shall use screw terminals for all field wiring.

## 2.9 SMOKE DETECTOR REMOTE STATUS AND ALARM INDICATORS

A. Remote power/alarm indicator and key switch. Contains green and red LED power/alarm indicators and keyed test/reset switch mounted on a stainless steel plate.

## 2.10 DEVICE GUARDS

A. Physical Damage Guards: 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.

B. Pull Station Protective Guard

1. The cover shall be provided for all manual pull stations.

2. Guard shall consist of a clear, tamperproof, tough polycarbonate shield, frame, and piezo horn,

3. When the protective guard with horn is lifted to gain access to the protected alarm, a piercing self-contained 95 or 105 dB warning horn (at one foot) shall sound.

4. The cover shall be connected to the frame by a cable. When the cover is lifted, the cover drops off of the frame and the horn shall sound until the cover is snapped back onto the frame.

## 2.11 FIRE ALARM WIRE AND CABLE

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. Comtran Corporation.
2. Draka Cableteq USA.

3. Genesis Cable Products; Honeywell International, Inc.
4. Rockbestos-Suprenant Cable Corp.
5. West Penn Wire; a brand of Belden Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, or twisted, unshielded pair, not less than No. 16 AWG. Refer to fire alarm system manufacturer for recommended sizes and shielding requirements.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.

## PART 3 - EXECUTION

### 3.1 VERIFICATION OF CONDITIONS (BY INSTALLER)

A. Verification of Conditions (by Installer): Examine conditions under which fire alarm system is to be installed in coordination with Installer of materials and components specified in this Section and notify affected Contractors and Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Architect written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.

### 3.2 PROTECTION

A. Protection: Provide dust covers on all detectors during construction.

### 3.3 EQUIPMENT INSTALLATION

A. Install fire alarm system in accordance with applicable provisions of NEC, NFPA-70, Article 760 - Fire Protective Signaling Systems.

1. Contractor performing fire alarm system work shall be a licensed fire alarm contractor. Contractor shall provide Fire Alarm Installation Certification with fire alarm system submittal.

2. Since existing fire alarm systems are being replaced, Contractor performing fire alarm system work shall comply with the requirements of the local Fire Marshall concerning the fire alarm system shutdown plans, procedures, and fire watch plans that will be implemented for system interruptions during construction. All existing fire alarm devices shall remain active until new cabling and devices are installed. Temporary interruptions are allowed while work is being done on the system. Work shall be coordinated so that system is fully functional at the end of the workday. If system is not fully functional at end of workday, Contractor shall provide personnel for fire watch as required by local Fire Marshall and shall be responsible for all associated costs.

3. Provide all labor, materials, equipment and services to perform all operations required for complete installation of fire alarm system and related construction as shown on Drawings and specified in this Section.

4. Completely check, program and adjust all new and existing equipment on each system.

5. Label each addressable device with label indicating device's unique address. Label shall comply with Specification Section 26 05 53 Identification for Electrical Systems. Labels shall be installed so that they are visible without removing device from mounting base.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections by testing 100% of system and submitting complete test reports.

1. Connect new equipment to existing control panel in existing part of the building.

2. Connect new equipment to existing monitoring equipment at the supervising station.

3. Expand, modify, and supplement existing equipment as necessary to extend existing functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.

2. Mount manual fire-alarm box on a background of a contrasting color.

3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

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. For smoke detectors, smooth ceiling spacing shall not exceed 30 feet (9 m).
4. For heat detectors, smooth 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 diffusers or return-air openings.
7. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

E. Install 200 deg. F. fixed temperature heat detectors in Kitchens and Boiler Rooms. Install 135 deg. F. fixed temperature heat detectors in areas where sudden temperature changes can be anticipated (near overhead doors, heating units, etc.).

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install supply duct detectors downstream of the air filters and ahead of any branch connections. Install return duct detectors between the air handling unit and any recirculation or fresh air inlet connection. Install sampling tubes so they extend the full width of duct.

G. Fan shutdown relays shall be wired to stop unit with motor controller's control switch in any position. Locate shut down relay within 3 feet of motor controller.

H. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

I. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

J. In areas where detection and notification devices may be subject to physical damage, devices shall have protective wire guards as manufactured by Safety Technology International (www.sti-usa.com). All guards shall be listed for the fire alarm system devices and appliances protected.

K. Install all devices on exterior of building in weatherproof enclosures supplied by device manufacturer.

L. In new construction, install all devices flush or semi-flush mounted, unless otherwise authorized by Owner.

M. In existing construction, install all interior surface mounted devices on surface mounted back boxes supplied by device manufacturer.

N. In locations where new devices are replacing existing, contractor shall coordinate removal/replacement to allow re-use of existing backbox/conduits if possible.

O. In locations where building construction prohibits flush-mounted installations, provide surface raceway. At such locations obtain written authorization from Owner's representative or Architect prior to providing surface raceway device.

P. Demolition of existing system:

1. Disconnect and remove existing fire alarm system in its entirety, inclusive of all wiring, devices, raceway, and controls.

2. Repair all damaged surfaces upon removal of existing devices and raceway. Repair and patch existing construction to match existing finishes.

Q. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

R. Remote Status and Alarm Indicators: Install near each duct detector, smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

S. Wire the Notification Appliance Circuits such that the audible alarm indicating devices can be turned off while the visual alarm notifications remain operational.

T. Locate audible/visible signaling devices in strict accordance with requirements of Americans with Disabilities Act (ADA).

U. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install speakers on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

V. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and place strobe light lens 80 inches minimum and 96 inches maximum above floor level. In locations where ceiling height is less than 90 inches AFF, place strobe light lens 6 inches below ceiling.

W. Where combination audible/visible units used, place strobe light lens 80 inches minimum and 96 inches maximum above floor level. In locations where ceiling height is less than 90 inches AFF, place strobe light lens 6 inches below ceiling.

X. Device Location-Indicating Lights: Locate in public space near the device they monitor.

Y. Fire-Alarm Control Panel: Surface mounted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

Z. Fire Alarm Graphic Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

## 3.4 WIRING

A. Install Type FPLP plenum rated fire alarm cable for all initiating circuit wiring and notification circuit wiring, sized in accordance with manufacturer's recommendations.

B. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

F. Install all plenum cable above corridor ceilings bundled and tie-wrapped at 5 foot intervals and hung in saddle rings or J-hooks, supported to structure at 5 foot intervals.

G. Cable shall not be considered properly supported by lying over top of conduits, piping, or building supports or bracing. Approved saddle rings or J-hooks must be used.

H. For wall mounted devices in existing construction where wiring cannot be concealed, all wiring shall be installed in surface metallic raceway from device location to an accessible ceiling space.

I. Install all wiring in approved surface metallic raceway or EMT conduit in the following locations:

1. Unfinished areas (EMT conduit).
2. Exposed areas (Surface metallic raceway).
3. Where subject to damage.

## 3.5 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 Division 08 Section "Door Hardware." 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 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 shutoffs for gas and fuel supplies.
4. Supervisory connections at valve supervisory switches.
5. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
6. Supervisory connections at elevator shunt trip breaker.

## 3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
B. Install framed instructions in a location visible from fire-alarm control panel.

## 3.7 GROUNDING

A. Ground fire-alarm control panel and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control panel.

## 3.8 ADJUSTING / CLEANING

A. Completely clean all smoke detectors, as instructed by authorized factory representative, when system is substantially complete and when authorized by Owner.

## 3.9 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Owner’s Representative and 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, and to assist in testing.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. 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.

b. 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. Perform 100 percent inspection and testing of all system devices.

    a. Provide complete panel real-time printout as documentation of device, date and time. Any acceptance test not accompanied by real-time printout requires retesting of entire system by Contractor, including both alarm activation tests and tests of supervisory circuit at each device.

    b. Provide inspection complying with requirements of applicable NFPA standards.

    c. Provide to Owner and Fire Code Official complete typed list of every initiation, signaling, control, supervisory and auxiliary device with specific information regarding system address of device, location of device, date tested, manufacturer's model number, and serial number of all analog components, status of device and zone or point as related to system. Obtain from Owner, the Owner's room names/numbers that are to be assigned to each device.

3. Take voltage readings at end of line of each alarm signal circuit to insure minimum operational levels.

    a. If voltage drop exceeds the minimum rating of the last device in the circuit, while under full circuit load, rewire circuits with appropriately heavier gage wire as required to comply with specified requirements.

4. 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.

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. Intelligibility Tests

1. Intelligibility testing of the System shall be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, IEC 60268-16, and ASA S3.2. Following are the specific requirements for intelligibility tests:

    a. Intelligibility Requirements: Verify intelligibility by measurement after installation.

2. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .7

3. The contractor must submit a waiver letter for areas of the building they believe will not meet the minimum CIS value at the beginning of the shop drawing phase. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.

4. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.

5. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).

6. The distance the occupant must walk to the location meeting the minimum required CIS value shall be measured on the floor or other walking surface as follows:

   a. Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.
   b. Curving around any corners or obstructions, with a 12 inch clearance there from.
   c. Terminating directly below the location where the minimum required CIS value has been obtained.

7. Use commercially available test instrumentation to measure intelligibility as specified by ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Annual Test and Inspection: One 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.

## 3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Training shall consist of a total of 8 hours delivered in 2 hour blocks.

B. Provide copy of sign-in sheet of District staff receiving training in O&M Manuals.

END OF SECTION 28 31 11

# SECTION 31 10 00 - SITE CLEARING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above and below-grade site improvements.
6. Disconnecting, capping or sealing, and removing site utilities.
7. Temporary erosion and sedimentation-control measures.
8. Disposal of waste material.

### 1.3 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil (insitu): Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

D. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated on Drawings.

E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

## 1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

## 1.5 SUBMITTALS, GENERAL

A. General: Submit all informational submittals required by this Section concurrently.

## 1.6 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or video.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

## 1.7 CLOSEOUT SUBMITTALS

A. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

## 1.8 PROJECT CONDITIONS

A. Verification of Conditions: Examine conditions under which site clearing is to be accomplished and notify Construction Manager and Architect in writing of any conditions detrimental to proper and timely accomplishment. Do not proceed with site clearing until unsatisfactory conditions have been corrected.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

E. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

F. Do not direct vehicle or equipment exhaust towards protection zones.

G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

H. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 31 20 00 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain. Flag each tree trunk at 54 inches above the ground.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

D. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction. Refer to Section 31 25 00, “Erosion and Sedimentation Controls”.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross tree or plant protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

## 3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site according to requirements in Section 31 25 00 "Erosion and Sedimentation Controls."

B. Should any trees or shrubs be damaged which are to be saved, arrange to have such damage treated by a licensed arborist or tree surgeon.

C. Protect tree and shrub root systems from smothering. Do not store construction materials, debris, or excavated material within plant protection zone. Do not permit vehicular traffic or parking within plant protection zone. Restrict foot traffic to prevent excessive compaction of soil over tree, shrub and turf root systems.

D. Trees or shrubs which die because of the Contractor's failure to conform to the Drawings and specifications shall be evaluated by a qualified organization selected by the Owner's Representative. The removal and replacement of the tree, and the evaluation expenses shall be paid for by the Contractor. Contractor shall be required to replace the damaged tree with plant material of comparable size and quality (i.e. damaged 12" caliper Red Maple shall be replaced by three 4" cal. or four 3" cal. Red Maples). Substitutions for variety shall be approved by the Architect.

## 3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.

B. Locate, identify, and disconnect utilities indicated to be abandoned in place.

C. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Construction Manager not less than ten (10) working days in advance of proposed utility interruptions.

D. Excavate for and remove underground utilities indicated to be removed.

## 3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots, obstructions, and debris to a minimum depth of 18 inches below exposed subgrade.
3. Use only hand methods for grubbing within protection zones.
4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer in accordance with Section 31 20 00 "Earth Moving".

## 3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Do not remove surplus topsoil from site.

D. Refer to Section 32 92 00 "Turfs and Grasses" for topsoil screening requirements.

E. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

F. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 72 inches.
2. Do not stockpile topsoil within protection zones.

## 3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction including foundations, slabs, paving, curbs, gutters, retaining walls, aggregate base and other improvements.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically. Leave cut edge neat and square where existing material is cut to adjoin new work.

2. Remove asphalt concrete paving material to full depth and remove from site. Do not use asphalt materials for on-site fill.

3. Gravel and stone fill under removed sidewalks may be reused if suitable for the particular new use and if approved by the Architect.

4. Break up and completely remove miscellaneous concrete, such as small foundations. Remove concrete, retaining walls or foundations below grade to a minimum depth of 2’.

5. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

## 3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 10 00

# SECTION 31 20 00 - EARTH MOVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Preparing subgrades for walks, pavements, turf and grasses.
2. Structural Fill: For backfill under structures, pavements, concrete pads, etc.
3. Granular Fill: Sub base for interior concrete slabs-on-grade, asphalt paving, concrete paving, etc.
4. Subsurface drainage fill for foundation drains, underdrains, etc.
5. Excavating and backfilling for buildings and structures.
6. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Requirements:

1. Section 03 30 00 - Cast-in-Place Concrete
2. Section 31 10 00 - Site Clearing
3. Section 32 92 00 - Turf and Grasses
4. Section 33 41 00 – Storm Utility Drainage Piping

### 1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Subbase: Granular aggregate layer supporting the slab-on-grade and pavement that also minimizes upward capillary flow of pore water.

G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Geotechnical Engineer.

2. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.

3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Geotechnical Engineer or Architect. Unauthorized excavation, as well as remedial work directed by Geotechnical Engineer or Architect shall be without additional compensation.

H. Fill: Soil materials used to raise existing grades.

I. Hazardous Soil Materials: Soils that are contaminated with petroleum product and/or hazardous chemicals, waste or industrial waste.

J. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. for bulk excavation or for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:

1. Rock Excavation: Track-mounted excavator rated at not less than 222-hp flywheel power with weight of 70,000 lbs or greater and a 30-in wide short-tip radius rock bucket. (Ratings are based on Caterpillar's "Model No. 330B”.)

K. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

L. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below aggregate base, structural fill, drainage fill, or topsoil materials.

M. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

N. Non-Granular Fill: Soil fill material used to raise existing grades in areas that do not require granular or structural fill.

O. Well-Graded: Soils containing a good range of all representative particle sizes between the largest and the smallest. All sizes must be represented, and no one size should be either overabundant or missing.

P. Poorly-Graded: Soils which either contain a narrow range of particle sizes or have some intermediate sizes lacking.

1.4 SUBMITTALS

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

B. Action Submittals:

1. Product Data: For each type of the following manufactured products required:

a. Geotextiles.
b. Warning tapes.

2. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

a. Classification according to ASTM D 2487.
b. Laboratory compaction curve according to ASTM D 698.
c. Submitted material testing and analysis shall demonstrate that no unsuitable soil groups are present.
d. Submitted material testing and analysis shall demonstrate that no absorbent clays are present.

3. Delegated-Design Submittal:

a. For excavations greater than or equal to 20 feet in depth require engineered systems design per OSHA requirements, signed and sealed by a professional engineer, and submitted for review.

4. Samples for Verification: For the following products, in sizes or quantities indicated below:

a. Fill: One-half gallon by volume of material in sturdy container of each type of fill, naming source for each material.
b. Geotextile: 12 by 12 inches.
c. Warning Tape: 12 inches long; of each color.

5. Verification of Conditions: Written confirmation from installer that installation of Earthwork Materials installed in accordance with specifications.

C. Informational Submittals:

1. Qualification Data: For qualified testing agency.

2. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, which might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: Qualified Installers as defined below:

1. Earthwork Contractor Experience Requirements: Provide a list of at least four Earthwork projects of comparable size, scope, and quality completed successfully by the proposed Sub Contractor within the past two years that includes the date completed, project Owner's name and current contact information, including telephone numbers and e-mail addresses.

B. Civil/Structural Preconstruction Conference: Attend Civil/Structural Preconstruction Conference.

## 1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: If work includes improvements on adjoining property, written authorization for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth moving operations.

D. Do not commence earth moving operations until temporary and permanent erosion- and sedimentation-control measures, specified in Division 31 Section "Erosion and Sedimentation Control" are in place.

E. Do not commence earth moving operations until plant-protection measures specified in Division 31 Sections "Erosion and Sedimentation Control" and "Site Clearing" are in place.

F. The following practices are prohibited within tree- or plant-protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

8. Directing vehicle or equipment exhaust towards protection zones.
9. Heat sources, flames, ignition sources, and smoking within or near protection zones.

G. Existing Hazardous Materials:

1. If during the performance of the work suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. If present, hazardous materials will be removed by Owner under a separate contract.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Soil Materials:

1. General: Provide imported soil materials when sufficient satisfactory soil materials are not available from onsite excavations.
2. Topsoil: Refer to Turf and Grasses Specification, Division 32.

B. Hazardous Materials:

1. Provide fill materials that are not contaminated with petroleum product, hazardous waste or industrial waste.
2. Contamination above federal, state or local requirements is not acceptable. Materials with a visible sheen or petroleum odor shall be rejected.

C. Unsuitable Soils: (Includes excavated native and imported non-granular, granular and structural fill materials)

1. Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

a. Soils Materials shall not contain any absorbent aluminum phyllosilicates, including but not limited to: bentonite (sodium, calcium, or potassium), tonstein, montmorillonite, kaolinite. or other absorbent clays.

2. Unsuitable soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

3. Submitted material testing and analysis shall demonstrate that material classification meets ASTM-D2487 USC system criteria and that no unsuitable soil groups, or absorbent clays are present.

D. Non-Granular Fill: Material is to comply with NYSDOT requirements for Select Borrow and Select Fill with modifications shown below. This material is not allowed in areas where granular soils are required, including within the building footprint, below pavement areas or below a synthetic turf athletic field.

1. On-Site Non-Granular Fill

    a. Submittal must be provided demonstrating that on-site soil material meets the criteria outlined in this Section for use as fill material.

    b. Obtain approval of Architect before proceeding with use of on-site material.

    c. Material is to have no particles greater than 3" in maximum dimension, no more than 70% by weight passing the #40 sieve and no more than 20% passing the #200 sieve.

    d. Testing submitted is to demonstrate that proper compaction can be achieved as required in Part 3, Execution.

2. Imported Non-Granular Fill

    a. Where quantity of approved non-granular fill materials required exceeds that available from on-site stock-piles, provide suitable material from off-site sources.

    b. Obtain approval of Architect before proceeding with use of imported fill material.

    c. Material is to have no particles greater than 3" in maximum dimension, no more than 70% passing by weight the #40 sieve and no more than 15% passing the #200 sieve.

    d. Testing submitted is to demonstrate that proper compaction can be achieved as required in Part 3, Execution.

E. Structural Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand.

1. Type 1 Fill (NYSDOT ITEM No. 304.11 Granular Fill) gradation requirements:

| **Sieve Designation** | **Percent by Weight Passing Square Mesh Sieves** |
|---|---|
| 3 inch | 100 |
| 2 inch | 90 to 100 |
| 1/4-inch | 30 to 65 |
| #40 | 5 to 40 |
| #200 | 0 to 10 |

F. Granular Fill: Import all granular fill types from off-site sources. Granular fill consists of stone, sand, and gravel, or blends of these materials, free of slag, complying with New York State Department of Transportation (NYSDOT) Standard Specification, Section 304, as modified below:

1. Type 2 Fill (NYSDOT ITEM No. 304.12 / Crushed / Blasted Ledge Rock Stone) Gradation Requirements.

| **Sieve Designation** | **Percent by Weight Passing Square Mesh Sieves** |
|---|---|
| 2 inch | 100 |
| 1/4-inch | 25 to 60 |
| #40 | 5 to 40 |
| #200 | 0 to 10 |

2. Type 4 Fill (NYSDOT ITEM No. 304.14 / Select Granular Fill) Gradation Requirements.

| **Sieve Designation** | **Percent by Weight Passing Square Mesh Sieves** |
|---|---|
| 2 inch | 100 |
| 1/4-inch | 30 to 65 |
| #40 | 5 to 40 |
| #200 | 0 to 10 |

G. Crushed Stone: Crushed stone to complying with New York State Department of Transportation (NYSDOT) Standard Specifications, Section 703-0201 which is product of mechanical crushing. Where indicated, provide the following fill materials, consisting of clean, free of slag, durable, sharp-angled fragments of rock of uniform quality. The crushed stone used as coarse aggregate for all items shall be obtained from sources conforming to the requirements of the NYSDOT as to sampling, testing methods, Quarry Reports and any other required procedures and complying with following requirements:

1. NYSDOT No. 1 Crushed Stone Gradation Requirements (NYSDOT 703-4 # 1 Stone):

| **Sieve Designation** | **Percent by Weight Passing Square Mesh Sieves** |
|---|---|
| 1 inch | 100 |
| 1/2-inch | 90 to 100 |
| 1/4-inch | 0 to 15 |
| #200 | 0 to 1 |

2. NYSDOT No. 2 Crushed Stone Gradation Requirements (NYSDOT 703-4 #2 Stone):

| **Sieve Designation** | **Percent by Weight Passing Square Mesh Sieves** |
|---|---|
| 1-1/2 inch | 100 |
| 1 inch | 90 to 100 |
| 1/2-inch | 0 to 15 |
| #200 | 0 to 1 |

H. Drainage Fill: Mixture of 50 percent NYSDOT No. 1 crushed stone and 50 percent NYSDOT No. 2 crushed stone, complying with New York State Department of Transportation Standard Specifications, Section 703-02.

| Sieve Designation | Percent by Weight Passing Square Mesh Sieves |
|---|---|
| 1-1/2 inch | 100 |
| 1 inch | 95 to 100 |
| 1/2-inch | 25 to 60 |
| # 4 | 0 to 10 |
| # 8 | 0 to 5 |

I. Sand for general use and/or utility bedding: ASTM C 33; fine aggregate.

J. Sand for storm water quality sand filter: Clean (washed) AASHTO M-6/ASTM C-33 medium aggregate coarse concrete sand, with effective particle size (D10) between 0.3mm and 0.5mm, a uniformity coefficient (Uc) of < 4, and < 4% fines passing the 100 sieve.

2.2 GEOTEXTILES

A. Separation/Filter Fabric - Nonwoven needle-punched polypropylene geotextile filter/separation fabric complying with the following:

| Fabric Property | Value | Test Method |
|---|---|---|
| Grab Tensile Strength | 120 lb | ASTM D 4632 |
| Grab Tensile Elongation | 50 percent | ASTM D 4632 |
| Trapezoid Tear Strength | 50 lbs | ASTM D 4533 |
| CBR Puncture Strength | 310 lbs min | ASTM D 6241 |
| Apparent Opening Size | No. 70 sieve max | ASTM D 4751 |
| Permittivity | 1.7 $sec^{-1}$ | ASTM D 4491 |
| Flow Rate | 135 gal $min/ft^2$ | ASTM D 4491 |
| UV Stability | 70% after 500 hours | ASTM D 4355 |

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. TenCate Mirafi - 140N
   b. Amoco - 4547
   c. Geotex – 451

B. Soil Stabilization Fabric: Heavy duty, commercially manufactured woven polypropylene geotextile meeting the following properties:

| Fabric Property | Test Method | Unit | Typical Value |
|---|---|---|---|
| Grab Tensile Strength | ASTM D 4632 | lbs | 200 |
| Grab Tensile Elongation | ASTM D 4632 | % | 15 |
| Trapezoidal Tear Strength | ASTM D 4533 | lbs | 75 min. |
| CBR Puncture Strength | ASTM D 6241 | lbs | 700 |
| UV Resistant after 500 hours | ASTM D 4355 | % Strength | 70 |
| Apparent Opening Size | ASTM D 4751 | US Sieve | 40 |
| Permittivity | ASTM D 4491 | $sec^{-1}$ | 0.05 |
| Water Flow Rate | ASTM D 4491 | $gal/min/ft^2$ | 4.0 |

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. TenCate Mirafi - 500X
   b. US Fabrics, Inc. - US 200
   c. Carthage Mills – FX-55
   d. Propex – 200 ST

C. Soil Stabilization Geogrid:

1. Geogrid manufactured from a punched polypropylene sheet, which is then oriented in three substantially equilateral directions so that the resulting ribs shall have a high degree of molecular orientation, which continues at least in part through the mass of the integral node.

2. Heavy duty, commercially manufactured Geogrid meeting the following properties:

| **Fabric Property** | **Test Method** | **Unit** | **Typical Value** |
|---|---|---|---|
| Rib Pitch - Longitudinal | ASTM D 4759-02 | Inch (nom.) | 1.60 |
| Rib Pitch - Diagonal | ASTM D 4759-02 | Inch (nom.) | 1.60 |
| Mid Rib Depth - Diagonal | ASTM D 4759-02 | Inch (nom.) | 0.05 |
| Mid Rib Depth - Transverse | ASTM D 4759-02 | Inch (nom.) | 0.05 |
| Mid Rib Width - Diagonal | ASTM D 4759-02 | Inch (nom.) | 0.04 |
| Mid Rib Width - Transverse | ASTM D 4759-02 | Inch (nom.) | 0.04 |
| Rib Shape | N/A | N/A | Rectangular |
| Aperture Shape | N/A | N/A | Triangular |
| Junction Efficiency | ASTM D 6637-10<br>ASTM D7737-11 | % | 93 |
| Radial Stiffness @ Low Strain | ASTM D 6637-10 | lb / ft @ 0.5% strain | 15,430 |
| Chemical Degradation Resistance | EPA 9090 | N/A | 100% |
| UV Light & Weathering Resistance | ASTM D 4355-05 | N/A | 70% |

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. Tensar Corporation - Triax TX140.

D. Subsurface Drainage Geotextiles: Refer to Division 33 Section "Storm Utility Drainage Piping".

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which earthwork is to be accomplished in coordination with Installer of materials and components specified in this Section and notify affected Prime Contractors and Architect in writing of any conditions detrimental to proper and timely accomplishment. Do not proceed with earthwork until unsatisfactory conditions have been corrected in manner acceptable to Installer.

1. When Installer confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied, submit to Architect written confirmation from applicable Installer. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to Installer.

### 3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

1. Contractor is entirely responsible for strength and adequacy of bracing and shoring, and for safety and support of construction from damage or injury caused by lack of adequate protection or by movement or settlement.

2. Contractors are advised that they are required to comply with Occupational Safety and Health Administration's (OSHA) standards pertaining to excavation.

3. All excavations must be barricaded at all times using either traffic or A-Frame type barricades. Gaps between barricades may be up to 6-inches wide and must be blocked with caution tape.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

### 3.3 UNDERGROUND UTILITY SURVEY

A. An underground utility survey must be conducted prior to the start of any excavation. Call 811

### 3.4 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

## 3.5 EXPLOSIVES

A. Explosives: Do not use explosives.

## 3.6 SITE CLEARING

A. Refer to Division 31 Section "Site Clearing".

## 3.7 EXCAVATION, GENERAL

A. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Geotechnical Engineer. Changes in the Contract Time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.

a. Intermittent drilling; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. Rock excavation includes removal and disposal of rock (refer to Definitions section: "Rock" paragraph above). Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:

a. 24 inches outside of concrete forms other than at footings.
b. 12 inches outside of concrete forms at footings.
c. 6 inches outside of minimum required dimensions of concrete cast against grade.
d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
e. 6 inches beneath bottom of concrete slabs-on-grade.
f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

## 3.8 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

## 3.9 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate trenches 6 inches (150 mm) deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe. Remove projecting stones and sharp objects along trench subgrade.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3. Cut and protect roots in accordance with standard nursery practice and Division 31 Section “Erosion and Sedimentation Control”.

## 3.10 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.
B. If Geotechnical Engineer determines that unsuitable soil is present, continue excavation and replace with compacted backfill or fill material as directed.

## 3.11 PROOF-ROLLING

A. Proof-roll subgrade below building slabs, concrete pads and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing 15 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction and repeating proof-rolling in direction perpendicular to first direction with a minimum of six overlapping passes. Limit vehicle speed to 3 mph.

2. Excavate soft spots, unsuitable soils, and areas of excessive pumping or rutting, as identified by Geotechnical Engineer and as directed by Owner, and replace with compacted backfill or fill as directed. Notify Architect in writing of any required remediation.

B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities without additional compensation.

## 3.12 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. CLSM (flowable fill), per this specification section, may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit in accordance with this Section unless otherwise directed by Geotechnical Engineer.

## 3.13 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

## 3.14 SOIL STABILIZATION GEOGRID

A. Install soil stabilization geogrid: After subgrade has been compacted and proof-rolled, install soil stabilization geogrid as specified by the manufacturer, including the following:

1. Unroll the geogrid in the direction of travel so that the long axis of the roll is parallel with channelized traffic patterns. Refer to manufacturer's installation requirements.

2. Overlap adjacent rolls along their sides and ends in accordance manufacturer's requirements.

3. Overlap geogrids in the direction the fill placement will be spread to avoid "peeling" of geogrid at overlaps by the advancing fill. Refer to manufacturer's installation requirements.

4. Refer to manufacturer's installation requirements for soil types requiring mechanical connection of adjacent geogrid rolls.

5. Insure that geogrid lies flat during fill placement.

6. Refer to manufacturer's installation requirements for geogrid tensioning and pinning, dumping and spreading of aggregate fill, and compaction.

## 3.15 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

## 3.16 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-Place Concrete".

D. Trenches under Roadways: Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-Place Concrete".

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Place and compact initial backfill of subbase material or satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

G. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.

H. Place and compact final backfill of satisfactory soil to final subgrade elevation.

I. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

J. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

## 3.17 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows. Refer to Part 2 for material requirements and specific conditions for the use of each type of soil material. All fill materials to be approved by Architect per requirements noted in Part 2.

1. Under grass and planted areas:

    a. Use satisfactory non-granular fill material.

2. Under walks, pavements and exterior slabs:

    a. Use Structural Fill below subbase layer and Type 2 granular fill for subbase layer.

3. Under steps and ramps

    a. Use structural fill below subbase layer and Type **2** granular fill for subbase layer.

4. Under catch basins, manholes, vaults or other underground structures.

    a. Use structural fill or as noted on drawings.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

## 3.18 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry density.

## 3.19 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Maximum layer depth before compaction:

1. Under Pavement: Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

2. Place backfill and fill soil materials in layers not more than 12 inches in loose depth for material compacted by heavy compaction equipment, and not more than 8 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry weight density according to ASTM D 1557:

1. Under walkways:

a. Scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.

2. Under natural turf or unpaved areas:

a. Compact each layer of subgrade backfill or fill soil material at 85 percent. Compact all layers beneath the upper 2'-0" to at least 95 percent.

3. Utility trenches:

a. Compact each layer of initial and final backfill soil material at 85 percent.

4. Landscape Planting Areas:

a. Compact each layer of subgrade backfill or fill soil material at 75 percent.

5. Under catch basins, manholes, vaults or other underground structures.

a. Scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.

## 3.20 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge and within +0” / -1” tolerance of bottom of slab.

## 3.21 SUBSURFACE DRAINAGE

A. Drainage Tubing / Subdrainage Pipe: Specified in Division 33 Section "Storm Utility Drainage Piping".

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench as shown in Drawings.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 with a minimum of two passes of a plate-type vibratory compactor.

## 3.22 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place granular fill base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place granular fill base course under pavements and walks as follows:

1. Place base course material over subgrade under hot-mix asphalt pavement.

a. If separation geotextile is shown in details, install on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.

2. Shape base course to required crown elevations and cross-slope grades.

3. Place base course 6 inches or less in compacted thickness in a single layer.

4. Place base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.

5. Compact base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

## 3.23 INSTALLATION OF SURFACE STONE MATERIAL

A. Place surface stone material (stone dust, cover stone, etc.) on subgrades free of mud, frost, snow, or ice.

B. Compact so that surface stone layer is consolidated. During installation avoid bringing subgrade material to the surface. If subgrade material becomes intermixed with surface stone, remove contaminated surface stone material and reinstall new surface stone.

## 3.24 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections unless otherwise noted.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Inspections and tests:

1. Geotechnical observations: Proof rolling procedures, site preparation, unsuitable soils removal, excavations, footing bearing, and fill placement.

2. Field Density Testing:

a. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Geotechnical Engineer.

b. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1) Fill under Footings: In each compacted fill layer, 1 compaction test for every 30 linear feet of wall may be taken. 1 compaction test may be made under each individual footing.

2) Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 50 feet or less of wall length, but no fewer than two tests.

3) Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2,000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.

4) Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

c. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3. Laboratory testing for on-site fills:

a. ASTM D 1557 Modified Proctor compaction curve including sieve analysis.

## 3.25 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Geotechnical Engineer or Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

## 3.26 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

# SECTION 31 23 00 - EXPANDED POLYSTYRENE GEOFOAM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Expanded Polystyrene (EPS) Geofoam.

### 1.3 REFERENCES

A. ASTM International (ASTM):

1. ASTM D6817 - Standard Specification for Rigid Cellular Polystyrene Geofoam.

### 1.4 SUBMITTALS, GENERAL

A. Submit all action submittals and informational submittals required by this Section concurrently.

### 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include product data and technical bulletins including materials, profiles, physical properties, and accessories, including:

1. Manufacturing materials and additives.
2. Preparation instructions and recommendations.
3. Installation methods.

B. Shop Drawings: Include the following:

1. Project specific layout plan, profiles and components.

### 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and installer.
B. Material Test Reports: From a qualified independent agency, submit summary of tests that products comply with specified performance requirements and ASTM D6817.

## 1.7 CLOSEOUT SUBMITTALS

A. Warranty.

## 1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: Minimum 5 years experience manufacturing similar products.
B. Installer Qualifications: Minimum 2 years experience installing similar products of the scope and complexity required for this project.
C. Source Limitation: Obtain geofoam through single source from single manufacturer.

## 1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's ordering instructions and lead time requirements.

B. Deliver products in manufacturer's unopened packaging bearing the brand name and manufacturer's identification until ready for installation.

C. Store and handle materials in accordance with the manufacturer’s instructions to avoid damage.

1. Protect from moisture and sunlight prior to installation.
2. Do not expose to open flame or other ignition sources.
3. Do not expose to organic solvents, petroleum products and their vapors.
4. Provide temporary ballast or other restraint prior to and during installation.

## 1.10 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

## 1.11 WARRANTY

A. Warranty: Manufacturer's standard warranty that products will maintain performance values in ASTM D6817.

1. Warranty Period: Ten years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 EXPANDED POLYSTYRENE (EPS) GEOFOAM

A. EPS Geofoam: Provide EPS geofoam, structural geotechnical engineering fill blocks, in locations and configurations as shown on the drawings and to meet the following properties:

1. EPS 22, 1.5#, Type II in accordance with ASTM D6817:

a. Minimum Density: 1.35 pounds per cubic foot.

b. Compressive Resistance:

1) At 1% Deformation: Minimum 7.3 psi, 1050 psf.
2) At 5% Deformation: Minimum 16.7 psi, 2400 psf.
3) At 10% Deformation: Minimum 19.6 psi, 2820 psf.

c. Elastic Modulus: 730 psi.

d. Flexural Strength: 35.0 psi.

e. Water Absorption, Maximum Total Immersion: 3 percent.

f. Oxygen Index: 24.0 percent.

g. Buoyancy Force: 61.1 pounds per cubic foot.

B. Products: Subject to compliance with requirements, available products that may be incorporated in the Work, include, but are not limited to:

1. Insulfoam, A Carlisle Company; Geofoam.
2. Shelter Enterprises, Inc; EPS Geofoam.
3. Thermal Foams Inc; Foam-Control Geofoam.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements to confirm site conditions are within the manufacturer's limits.
B. Proceed with installation only after unsatisfactory conditions have been corrected.
C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

### 3.2 PREPARATION

A. Excavate and prepare subgrade in accordance with the manufacturer's instructions and project documents.

B. Verify engineered depths, product thicknesses, and other conditions which would affect installation.
C. Examine geofoam prior to installation. Reject materials that have been damaged and replace.
D. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

## 3.3 INSTALLATION

A. Install in accordance with the manufacturer's current published instructions, and details and drawings issued for the project.

1. Conflicts between the manufacturer instructions and project documents shall be resolved in writing prior to construction.

## 3.4 PROTECTION

A. Protect installed products and surface finishes from damage during construction
B. Remove and legally dispose of construction debris from project site.

END OF SECTION 31 23 00

# SECTION 31 25 00 - EROSION AND SEDIMENTATION CONTROLS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Erosion, sediment and pollution controls as shown on the Drawings and as directed by the Architect to significantly reduce runoff on downstream properties. This includes temporary control measures to mitigate land disruption by other contractors during construction of this project.

2. Erosion, sediment and pollution control includes, but is not limited to, the following:

   a. Standard control measures such as storm structure protection, silt fence, silt fence dikes, and rip rap.
   b. Off site sediment tracking controls.
   c. Sedimentation basin.
   d. Seeding, sodding and erosion control fabric.
   e. Rock check dam, sediment trap and detention basin with weir.
   f. Temporary protection for existing vegetation.
   g. Clean up.

3. Comply with the Soil Erosion and Sediment Control (SESC) for this Project in consultation with appropriate local agencies and soil conservation service. *Any local or State Agency requirements are considered part of these specifications.*

### 1.3 SUBMITTALS, GENERAL:

A. General; Submit all action submittals and informational submittals required by this section concurrently.

### 1.4 ACTION SUBMITTALS

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

1. Filter fabric and hardware cloth for storm structure protection.
2. Silt fence and silt fence dikes.
3. Straw bales
4. Stakes

5. Erosion control blanket
6. Turf reinforcement matting
7. Soil stabilization fabric for off-site sediment tracking control.
8. Bonded fiber matrix
9. Channel drain inlet filter matting
10. Drop-In Inlet Protection

B. Material Certificates: Materials certificates showing content/mechanical analysis are required for the following products. Also, provide samples as noted.

1. Granular Backfill: Sample.
2. Granular Base Course Material: Sample.
3. Seeding & sodding.
4. Rip rap.
5. No. 4 stone for off site sediment tracking control.
6. 4,000 psi concrete.

## 1.5 INFORMATIONAL SUBMITTALS

A. Quality Control Submittals

B. Qualifications Certification: Submit written certification or similar documentation signed by applicable subcontractor, Contractor and manufacturer (where applicable) indicating compliance with applicable “Qualifications” requirements specified below in “Quality Assurance” article.

C. Installer Experience Listing: Submit list of completed projects using products proposed for this Project, including owner’s contact and telephone number for each project, demonstrating compliance with applicable “Qualifications” requirements specified below in “Quality Assurance” article.

## 1.6 QUALITY ASSURANCE

A. Perform erosion, sediment and pollution control in compliance with applicable requirements of the New York Standards and Specifications Erosion and Sediment Control and other governing authorities having jurisdiction.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Handle and store products according to manufacturer's written instructions.

## 1.8 NOTICES

A. Pre-Construction Conference: Within seven days of start of construction, attend Civil/Structural Preconstruction Meeting. Representatives of all Contractors responsible for earthwork operations are required to attend.

B. When the site has been finally stabilized, Contractor will notify the Architect, in writing, that a final inspection be performed.

C. Pay any fines issued by any agency as a result of non-compliance with the SESC Plans.

1.9 INSPECTIONS AND MAINTENANCE

A. The Architect or qualified personnel of the Owner shall inspect disturbed areas of the construction site. Special attention will be focused on areas not finally stabilized, structural control measures, and locations where vehicles enter or exit the site. Disturbed areas will be inspected for pollutants entering the drainage system. Structural control measures will be reviewed for effectiveness in preventing significant impacts to receiving waters. Locations where vehicles enter or exit the site will be inspected for evidence of off-site sediment tracking.

B. Provide timely maintenance of vegetation erosion and sediment control measures, and other protective measures, during construction.

C. Perform corrective measures within three calendar days of the Architect's or Owner's report at no cost to the Owner. Failure by the Contractor to perform corrective work within this schedule automatically authorizes the Owner to hire others and deduct from the Contract Sum the costs incurred by the Owner for the performance of this Work.

PART 2 - PRODUCTS

2.1 STORM SEWER PROTECTION

A. 1/2-inch mesh hardware cloth covered with a polypropylene silt fence fabric (see below).

2.2 SILT FENCE

A. Meet the following criteria unless specific type is shown on plans or Architect accepts the change in criteria.

1. Silt Fence: Polypropylene filter fabric supported by non-pressure treated hardwood posts meeting the following requirements.

| Property | Unit | Test Method | Value |
|---|---|---|---|
| Grab Tensile Strength (Machine Direction) | lbs | ASTM D 4632 | 124 min |
| Grab Tensile Strength (Cross-Machine Direction) | lbs | ASTM D 4632 | 124 min |
| Grab Tensile Elongation | % | ASTM D 4632 | 15 / 15 |
| Trapezoid Tear Strength | lbs | ASTM D 4533 | 65 min |
| Mullen Burst Strength | psi | ASTM D 3786 | 300 min |
| Puncture Strength | lbs | ASTM D 4833 | 60 |
| Ultraviolet Stability (Strength Retained) | % | ASTM D 4355 | 70 |
| Apparent Opening Size (AOS) | U.S. Sieve | ASTM D 4751 | 30 |
| Permittivity | $sec^{1}$ | ASTM D 4491 | 0.10 |
| Coeff of Permeability | CM/Sec | ASTM D 4491 | 0.005 min |
| Water Flow Rate | $gal/min/ft^2$ | ASTM D 4491 | 10 min |

2. Basis of Design Product: Subject to compliance with requirements provide Tencate Geosynthetics Mirafi 100X fabric or comparable product.

3. Reinforced fence: Fabric backed with 14-1/2 gauge by 6 inch square mesh woven wire. See plans and details for specific locations or requirements.

B. 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. DGI Industries.
2. Hanes Geo Components.
3. TenCate Geosynthetics (Mirafi).

## 2.3 STAKES

A. One of the following:

1. 2-inch by 2-inch nominal by 4-feet long, non-pressure treated hardwood.
2. #4 rebar, 4-feet long min.

B. Maximum post spacing permitted shall be: 8'4" O.C.

## 2.4 STONE FILTERS

A. Size shown on the plans meeting the requirements of ASTM C33 or State specifications where applicable.

## 2.5 PERMANENT SEEDING AND SODDING

A. Refer to applicable section.

## 2.6 TEMPORARY SEEDING (unless otherwise shown on Drawings):

A. Minimum Requirements:

1. Lime: 1/2 ton per acre.
2. Fertilizer: Commercial 5-10-10 or equivalent (600 lbs per acre).
3. Seed: Ryegrass (annual or perennial) (40 lbs. per acre).
4. Mulch: Straw at 2 ton per acre.

## 2.7 EROSION CONTROL BLANKETS

A. On Slopes less than 3:1 – Netless Biodegradable Blanket: 100% biodegradable stitched excelsior erosion control matting. (Netted erosion control fabric on slopes flatter than 3:1 is not allowed.)

1. Material Characteristics:

   a. Soil loss ratio: .063
   b. Fiber Size: 80% of fibers min. of 6 inches long
   c. Weight: 0.73 lb per square yard.
   d. Suitable for channel flows up to 3.0 ft./second and 1.0 lb/ft. shear stress.

2. Staples: Use manufacturer provided staples.

3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. "Curlex NetFree" Erosion Control Blanket manufactured by North American Green.

B. On Slopes Steeper than 3:1 up to 1.5:1 – 100% biodegradable excelsior erosion control matting with polypropylene netting containing a UV degrader additive.

1. Material Characteristics:

   a. Fiber Count: 7,000 per square yard.
   b. Fiber length: 80% of fibers min. of 6" long
   c. Net Openings: 1.0 inch x 2 inches
   d. Thickness: 0.411 inch per ASTM D 6525
   e. Swell: 49% per ECTC Procedure
   f. MD-Tensile Strength Max.: 74.4 lb./ft. per ASTM D 6818
   g. TD-Tensile Strength Max.: 36.0 lb./ft. per ASTM D 6818

2. Staples: Use manufacturer provided staples.

3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. "Curlex I QuickMow" Erosion Control Blanket manufactured by North American Green.

C. Within High Water Line or Floodway – Extended-term biodegradable fiber matrix with coconut fibers. Functional longevity to be 18 months with maximum flow velocity of 8.0 ft/s. Functional longevity to be 18 months with maximum flow velocity of 8.0 ft/s.

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. Product No. SC150BN manufactured by North American Green.

## 2.8 TURF REINFORCEMENT MATTING

A. Permanent erosion control/turf reinforcement mat constructed of a matrix of polypropylene monofilament yarns woven into uniform configuration of resilient pyramid-like projections.

1. Material Properties:

| Property | Test Method | Units | Property Requirement |
|---|---|---|---|
| Thickness | ASTM D-6525 | mm (in) | 10.2 (0.40) |
| Resiliency | ASTM D-6524 | percent | 80 |
| Mass Per Unit Area | ASTM D-6566 | G/sq m (oz/sy) | 455 (13.5) |
| Tensile Strength | ASTM D-6818 | kN/m (lbs/ft) | 58.4 x 43.8 (4,000 x 3,000) |
| Tensile Elongation | ASTM D-6818 | percent | 65 (max) |
| Light Penetration (% Passing) | ASTM D-6567 | percent | 10 |
| UV Resistance | ASTM D-4355 | percent | 90 at 6000 hrs |

2. Performance Properties: In a vegetated state, the RECP must demonstrate acceptable performance (as defined by the Engineer) when subjected to at least 0.5 hrs of continuous flow producing the following conditions:

   a. Permissible velocity: 7.6 m/sec (25 ft/sec)
   b. Permissible tractive force (shear stress): 0.718 kPa (15 psf)

3. Color: Green.

4. Basis of Design Product: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Pyramat Geotextile System by Propex, Inc.

## 2.9 STABILIZED CONSTRUCTION ENTRANCE

A. No. 4 stone meeting the following requirements:

| Standard ASTM Sieve Size | Percent Passing by Weight |
|---|---|
| 4 inch | 100 |
| 3 inch | 90-100 |
| 2 inch | 0-15 |
| Passing No. 50 | 5-10 |
| Passing No. 100 | 2-5 |

B. Soil Stabilization Fabric:

1. Stabilization Fabric: Commercially manufactured, UV stabilized low clogging, high flow, woven geotextile meeting the following requirements.

| Property | Unit | Test Method | Value |
|---|---|---|---|
| Grab Strength | lbs | ASTMD-4632 | 315 min |
| Tensile Strength | lbs/in | ASTMD-4595 | 175 min |
| Grab Elongation | % | ASTMD-4632 | 15 max |
| Trapezoid Tear | lbs | ASTMD-4533 | 120 min |
| Mullen Burst | psi | ASTMD-3786 | 600 min |
| Permittivity | /Sec | ASTMD-4491 | .05min |
| Water Flow Rate | gal/min/ft$^2$ | ASTMD-4491 | 4 min |

2. Basis of Design Product: Subject to compliance with requirements provide Tencate Geosynthetics Mirafi 600X fabric or comparable product.

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. DGI Industries.
   b. Hanes Geo Components.
   c. TenCate Geosynthetics (Mirafi).

C. Granular Base Course Material: Shall be as specified in Earth Moving Section.

## 2.10 TEMPORARY TREE PROTECTION

A. Stakes: shall be a 2 inch by 4 inch by 6 feet (min) non-pressure treated hardwood.

B. Top Rail: shall be 2 inch x 4 inch x 8 feet (max) non-pressure treated hardwood fastened to stakes by nails or screws.

C. Fabric: Heavy duty orange construction barrier fencing similar to “Sentry HD” fencing by Tenax Corporation Baltimore Maryland. Fabric shall be attached to the stakes and top rails with staples or other fasteners.

## 2.11 OUTLET SEDIMENTATION TRAP

A. Outlet Sedimentation Trap: Constructed of 12 inch pipe, AASHTO M294-Type S or SP corrugated HDPE N-12 pipe and stone as shown in the Drawings. Filter fabric shall be as specified for siltation fence. Hardware cloth shall be ½ inch mesh. Concrete shall be 4,000 psi.

## 2.12 ROCK CHECK DAMS AND SEDIMENT TRAPS

A. Provide stone rip rap as specified. Vegetation shall be as described on the Drawings.

## 2.13 BONDED FIBER MATRIX

A. Hydraulically applied continuous layer of biodegradable elongated fiber strands held together by a water-resistant bonding agent with no holes greater than one millimeter in size.

B. Physical Components:

1. Ingredients/Composition:

a. Gypsum-based, soil beneficial binder
b. Cellulosic fiber mulch (paper/soft wood)
c. Plant-based tackifiers (short-term binding agents)
d. Nonpetroleum-based polymers (long-term binding agents)
e. Surfactant
f. Water-holding polyacrylmides (PAM)

C. Physical Properties:

1. Moisture: 10% (+/- 2%)
2. pH: 5.5 – 6.5
3. Mix: 70lbs (+/-10 lbs.) per 100 gallons of water (Recommended)
4. Color: Green
5. Wood/Cellulose Fiber: 70% / 30%
6. Water Holding ASTM D 7367-07: 850-950%
7. Water Holding ASTM Modified Method: 1200 – 1400%

D. 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. "Enviro-Shield" Brand Bonded Fiber Matrix by USG.
2. "Flexterra" by Profile Products, LLC.

## 2.14 CHANNEL DRAIN INLET FILTER MATTING:

A. Latex bonded coir (coconut) fiber matting, 4.0 Ounces per Square-Foot, 1-1/2" thickness.

B. Basis-of-Design product and standard of quality for channel drain inlet filter matting for use in existing and proposed channel drains shall be Natural Fiber Inlet Filter Matting, Item #IF1527X75FTB, by Blocksom & Co., Michigan City, Indiana. Telephone: 800-745-1408. Web: www.blocksom.com

C. Physical Properties: (4-inch wide strip specimen)

1. Fiber Material

a. Latex bonded coir (coconut) fiber matting
b. Nominal 4.0 ounces / square-foot, 1½" thickness.

2. Sediment Control per ASTM D 5141

    a. Test Material: Sand sieved through No. 10 sieve
    b. Efficiency: 59.1%
    c. Minimum flow rate: 150 liters/minute

3. Tensile Properties per ASTM D 5035/ECTC

    a. MD – Maximum Load: 14.6 ppi
    b. TD – Maximum Load: 18.7 ppi
    c. MD – Elongation at Max Load: 19.3%
    d. TD – Elongation at Max Load: 27.7%

4. UV Resistance per ASTM D 4355 – 500 hr exposure

    a. MD – Maximum Load: 10.2 ppi
    b. TD – Maximum Load: 13.8 ppi
    c. MD – Elongation at Max Load: 16.9%
    d. TD – Elongation at Max Load: 16.6%

5. Smolder Resistance (ECTC)

    a. Maximum Burn Distance: 0.29 in

6. Light Penetration (ECTC Guidelines)

    a. Baseline Reading: 125
    b. Reading with Sample: 10
    c. Percentage Light Penetration: < 8%

7. Resiliency per ASTM D 6524

    a. Pre-Loading Thickness: 1943 mils
    b. Post-Loading Thickness: 326 mils
    c. Percentage Change: -83%

8. Swell (ECTC)

    a. Dry Thickness: 1984 mils
    b. Thickness after Soak: 2098 mils
    c. Percentage Change: 6%

9. Water Absorption per ASTM D 1117/ECTC

    a. Pre-Soak Weight: 69 grams
    b. Post-Soak Weight: 152 grams
    c. Weight Change: 82 grams
    d. Percentage Weight Change: 119%

10. Mass/Unit Area per ASTM D 6565

    a. Mass/unit area: 50.89 oz/sq yd
    b. Mass/unit area: 1725 g/sq meter

11. Filter Mat Filter Cable Ties

    a. Heavy duty "zip" cable ties provided by filter manufacturer and designed specifically for inlet filter product, and in quantity required for manufacturer recommended installation method.

2.15 DROP-IN INLET PROTECTION:

A. Standard of quality for aftermarket inlet protection for use in existing and proposed catch basin, drop inlets, curb box inlets and storm manholes shall be Flexstorm Inlet Filters, by Inlet and Pipe Protection, Inc., Naperville, Illinois.

1. Description of System:

    a. An aftermarket drop-in inlet filter system designed to collect silt and sediment from surface storm water runoff at drainage locations shown on the plans, at existing inlets in pavement where adjacent disturbance will allow sediment runoff to occur, in areas where access to the site dictates their use due to phasing issues, or as directed by the Engineer.

    b. An aftermarket drop-in inlet filter system comprised of a corrosion resistant steel frame and a replaceable geotextile sediment bag attached to the frame with a stainless steel locking band. The sediment bag hangs suspended from the rigid frame at a distance below the grate that shall allow full water flow into the drainage structure if the bag is completely filled with sediment.

    c. The aftermarket drop-in inlet filter frame includes lifting handles in addition to the standard overflow feature. A proprietary Removal Tool engages the lifting bars or handles to allow manual removal of the assembly without machine assistance. The frame suspension system is adjustable in ½" increments up to 5" per side on rectangular designs should the casting or drainage structure have imperfections.

    d. Standard woven polypropylene sediment bags with a typical flow rate of 200 gpm / sq ft.

2. Woven Sediment Bag Material Specifications:

| | | MARV[2] | |
|---|---|---|---|
| PROPERTY | TEST METHOD | ENGLISH | METRIC |
| Mechanical | | | |
| Tensile Strength ( Grab ) | ASTM D-4632 | 255 x 275 lbs | 1130 x 1220 N |
| Elongation | ASTM D-4632 | 20 x 15 % | 20 x 15 % |
| Puncture | ASTM D-4833 | 135 lbs | 600 N |
| Mullen Burst | ASTM D-3786 | 420 psi | 2890 kPa |
| Trapezoidal Tear | ASTM D-4533 | 40 x 50 lbs | 175 x 220 N |
| Endurance | | | |
| UV Resistance | ASTM D-4355 | 90% | 90% |
| Hydraulic | | | |
| Apparent Opening Size (AOS)[3] | ASTM D-4751 | 20 US Std. Sieve | 0.850 mm |
| Percent Open Area (POA) | CW-02215 Mod.[4] | 20% | 20% |
| Permittivity | ASTM D-4491 | 1.50 $sec^{-1}$ | 1.50 $sec^{-1}$ |
| Water Flow Rate | ASTM D-4491 | 200 $gpm/ft^2$ | 8,145 $l/min/m^2$ |

3. Tested Filtration Efficiency:

a. All testing performed in general accordance with the ASTM D 7351, *Standard Test Method For Determination of Sediment Retention Device Effectiveness in Sheet Flow Application*, with flow diverted into an area inlet. Test Soil used as sediment had the following characteristics with a nominal 7% sediment to water concentration mix:

| Soil Characteristics | Test Method | Value |
|---|---|---|
| % Gravel | ASTM D 422 | 2 |
| % Sand | | 60 |
| % Silt | | 24 |
| % Clay | | 14 |
| Liquid Limit, % | ASTM D 4318 | 34 |
| Plasticity Index, % | | 9 |
| Soil Classification | USDA | Sandy Loam |
| Soil Classification | USCS | Silty Sand (SM) |

**Tested Efficiencies:**

| Property | Woven Sediment Bag |
|---|---|
| Filtration Efficiency | 82% |

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Examine conditions under which soil erosion and sediment control is to be installed notify Architect in writing of any conditions detrimental to proper and timely installation. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

B. Beginning installation constitutes Contractor's acceptance of substrate and conditions.

### 3.2 GENERAL EROSION CONTROL

A. Install initial construction erosion control features, as indicated on SESC Drawings and Specifications or as directed by the Architect, prior to topsoil stripping, earthwork, and removal of existing vegetation. Keep the disturbance to a minimum. Install other features as described in the sequence of erosion, sediment and pollution control on the drawings.

B. Minimize amount of bare soil exposed at one time. Cumulative disturbance in excess of one acre requires coverage under NYSDEC SPDES Permit for Construction Activities.

C. Start permanent seeding within seven calendar days of rough grading. When this is not possible, provide temporary seeding of perennial rye grass at the rate of three pounds seed per one thousand square feet. Provide temporary seeding within seven days on non-roof, non-paved areas. When adverse weather conditions prevent good germination, repeat seeding as directed by the Architect until the area is stabilized. Till under temporary grass and fine grade when preparing for final seeding.

D. Until a disturbed area is stabilized, trap runoff sediment by the use of debris basins, sediment basins, silt traps, or other methods acceptable to the Architect and governing authorities. Construct sediment basins to dimensions shown on plans.

E. Place stone filters in accordance with dimensions shown on Drawings. If filters become plugged or partially plugged, remove and replace the stone. Cleaning of stone will only be allowed when method is reviewed by Owner Representative and found acceptable.

F. Provide erosion controls on slopes and swales traversing, bordering, or leaving the site. Limit the water flow to a non-erosive velocity.

G. Do not store fill materials within fifty feet of the banks of any streams or water bodies, intermittent or perennial.

H. Provide temporary protection for Trees and Shrubs as outlined and shown on Drawings and elsewhere in this Section.

I. Inspect erosion and sediment control measures immediately after each rainfall and at least daily during prolonged rainfall. Make required repairs immediately.

J. Remove sediment deposits when they reach approximately one-half of the height of the barrier. Dispose sediment in a manner that does not result in additional erosion or pollution.

K. Provide prompt removal and disposal of rubbish and debris in accordance with the governing authorities.

L. Coordinate temporary erosion and sediment control measures with permanent erosion control features specified elsewhere in the Contract Documents to the maximum extent possible to assure economical, effective, and continuous erosion control.

M. Remove all temporary measures at completion of construction.

## 3.3 MUNICIPAL SEWER AND WETLAND EROSION CONTROL

A. Control erosion, siltation and pollution to municipal sewers, water bodies and wetlands by taking appropriate measures such as, but not limited to, the following:

1. Prevent petroleum products and excessive amounts of silt, clay, and muck from entering municipal sewers, waters or wetlands of New York State during construction.

2. Prevent fresh concrete, concrete leachate and washings from equipment and trucks, from entering municipal sewers, waters or wetlands of New York State during construction.

3. Place silt fence to control erosion at the down slope edge of disturbed areas. Place this barrier to sediments before disturbance of the ground occurs and maintain in good condition until disturbed land is heavily vegetated or otherwise permanently stabilized.

4. Seed areas of soil disturbance resulting from this Project with appropriate perennial grass seed and mulch with straw within seven calendar days as described in general erosion control. Maintain mulch until a suitable vegetative ground cover is established.

## 3.4 STORM STRUCTURE PROTECTION

A. As shown on the Soil Erosion and Sediment Control Plans (SESC), provide storm structure protection at each inlet as shown on the detail plan. Clean storm structure protection material after each storm event to permit the fabric and/or drainage stone to work effectively. Remove the drainage material when the site is stabilized and approved by the Architect.

## 3.5 SILT FENCE/STRAW BALE DIKES

A. Locate in accordance with plans and details and as directed by the Architect. Excavate trench along the lower perimeter(s) of site, along the contract limit line, and as indicated on the Drawings. The placement of silt fence and/or bales shall consider drainage paths and intercept drainage prior to leaving site or entering storm system. Place excavated material on uphill side of trench for backfilling.

B. Drive stakes securely into the downhill side of the trench. When prefabricated silt fence with fabric attached to stakes is used, drive stakes so that fabric is buried in the ground as detailed.

C. Backfill trench with excavated material, so that fabric is securely buried in the ground to prevent undermining. Tamp soil.

D. Join sections by overlapping fabric between two stakes. Set stakes simultaneously. Overlap by minimum six inches, fold, and staple to prevent sediment bypass.

E. Attach silt fence securely to stakes spaced no more than eight feet on center. Secure fence fabric to stake with minimum three one inch staples.

F. Provide silt fence dikes perpendicular to swale center lines in swales one and one half percent and steeper. Locate dikes at a maximum interval of fifty feet on center unless otherwise shown on drawings.

G. Removal of silt and replacement of silt fence and/or bales shall be on going throughout the duration of the project to maintain an effective silt removing barrier.

## 3.6 TEMPORARY SEEDING

A. When necessary, provide temporary seeding as described in this Section.

B. Seedbed Preparation:

1. Scarify soil if compacted.
2. Remove debris and obstacles such as rocks and stumps.
3. Apply lime and fertilizer.
4. Apply seed uniformly by mechanical seeder or hydroseeder.
5. Apply straw mulch.

C. Provide permanent seeding as described elsewhere in the Contract Documents.

## 3.7 EROSION CONTROL MAT

A. Install on all slopes 3:1 or steeper and where indicated on Drawings. Install in accordance with manufacturers' recommendations and design details, including number and location of staples.

## 3.8 TURF REINFORCMENT MATTING

A. Install where indicated on Drawings. Install in accordance with manufacturers' recommendations and design details, including number and location of staples.

## 3.9 BONDED FIBER MATRIX

A. Hydraulically install bonded fiber matrix in strict accordance with manufacturer's installation instructions at the maximum rate given.

B. Typical Application Rates:

1. <3:1 Slope: 3,000 lbs./acre
2. 3:1 < 2:1 Slope: 3,500 lbs./acre
3. >2:1 Slope: 4,000 lbs./acre

C. Limitations: Do not use this product in the following conditions. Notify Architect if these conditions exist.

1. Concentrated overland water flow.
2. On soils that display deep-seated instabilities.
3. Where soil compaction problems exist or on soils that are subjected to frost heave and/or surface peeling (loosening of top layer of soil).

D. Store and handle material per manufacturer's requirements.

## 3.10 OFFSITE SEDIMENT TRACKING CONTROLS

A. Stabilization Blanket: Install as detailed and shown on Drawings to eliminate tracking sediment off site. Inspect after each rain storm and at least one time per week. When sediment begins tracking off site, immediately replace stone with clean No. 4 stone to retain sediment on site. Remove fabric and stone at project completion. Complete construction of proposed final surface(s).

## 3.11 OUTLET SEDIMENTATION TRAP

A. Install as detailed. Remove temporary trap and install permanent end section per detail near end of project when directed by the Architect.

## 3.12 ROCK CHECK DAMS AND SEDIMENT TRAPS

A. Install rip rap and vegetation as detailed on the Drawings and described elsewhere in the Contract Documents.

## 3.13 CHANNEL DRAIN INLET FILTER MATTING

A. Install channel drain inlet matting per manufacturer's installation requirements.

B. Cut matting if necessary to allow minimum 3" overlap at each side of the grate. Attach the mat to the topside of the inlet grate using cable ties.

C. Clean silt from around channel inlet matting following each rain event and as required by the Soil Erosion and Sediment Control plans and specifications, and as dictated by the Storm Water Pollution and Prevention Plan (SWPPP). Sweep the top of mat to clear built-up silt and solids, and dispose of. Do NOT allow accumulated sediment to enter the inlet.

## 3.14 DROP-IN INLET PROTECTION

A. Install channel drain inlet matting per manufacturer's installation requirements.
B. Clean silt from filter bag following each rain event and as required. Do NOT allow accumulated sediment to enter the inlet.

## 3.15 TREE PROTECTION

A. Temporary Protection for Trees and Shrubs:

1. Provide temporary fencing, barricades or guards as required to protect trees and other plants, which are to remain, from above ground damage.

2. Protect root system from smothering. Do not store construction materials, debris, or excavated material within drip line (outer perimeter of branches). Do not permit vehicular traffic or parking within drip line. Restrict foot traffic to prevent excessive compaction of soil over root systems.

3. Should any trees or shrubs be damaged which are to be saved, arrange to have such damage treated by a licensed arborist or tree surgeon.

4. Trees or shrubs which die because of the Contractor's failure to conform to the Drawings and specifications shall be evaluated by a qualified organization selected by the Owner's Representative. The removal and replacement of the tree, and the evaluation expenses shall be paid for by the Contractor. Contractor shall be required to replace the damaged tree with plant material of comparable size and quality (i.e. damaged 12 inch caliper Red Maple shall be replaced by three 4 inch cal. or four 3 inch cal. Red Maples). Substitutions for variety shall be approved by the Architect

## 3.16 CLEANING

A. During the Contract and at intervals as directed by the Architect and as erosion, sediment and pollution control procedures are completed, clear the site of extraneous materials, rubbish, and debris. Leave the site in a clean, safe, well draining, and neat condition.

B. Clean storm ponding areas, catch basins, detention basins, and Oil and Grit Separator(s): Clean out contaminants, sediment, rubbish, construction debris, foreign objects and accumulated floatables from chambers and ponding areas thoroughly, immediately prior to final acceptance.

END OF SECTION 31 25 00

# SECTION 32 12 16 - ASPHALT PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
B. The principle reference for materials and methods is the “New York State Department of Transportation Standard Specifications for Construction and Materials,” latest edition (NYSS).

### 1.2 SUMMARY

A. Section Includes:

1. Hot-mix asphalt paving.
2. Hot-mix asphalt patching.
3. Pavement-marking paint.

B. Related Sections:

1. Section 31 20 00 "Earth Moving" for subgrade and aggregate base preparation and other requirements.

### 1.3 SUBMITTALS

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

B. Action Submittals:

1. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

a. Job-Mix Designs: For each job mix proposed for the Work.

C. Qualification Data:

1. Asphalt Paving Installer Experience Listing: Submit list of completed projects using products proposed for this Project demonstrating compliance with applicable requirements specified below in “Quality Assurance” article.

2. Manufacturer’s Certificates: Certify that hot mix asphalt products meet or exceed NYSDOT Standard Specifications:

a. Section 401: Plant Production
b. Section 402: Hot Mix Asphalt (HMA) Pavements
c. Section 407: Tack Coat
d. Section 685: Pavement Markings

## 1.4 QUALITY ASSURANCE

A. Manufacturer and Mixing Plant Qualifications: A paving-mix manufacturer and mixing plant with NYSDOT approved materials and batch plant equipment complying with the following NYSDOT Standard Specifications:

1. Section 401: Plant Production
2. Section 402: Hot Mix Asphalt (HMA) Pavements.

B. Asphalt Paving Installer: Company specializing in performing work described in this section with minimum experience of three years.

C. Permits: Submit certified copies of all permits obtained from local regulatory agencies and New York State Department of Transportation.

D. Installation Requirements: Work to be performed in accordance with the following NYSDOT Standard Specifications:

1. Section 402: Hot Mix Asphalt (HMA) Pavements
2. Section 407: Tack Coat

## 1.5 REGULATORY REQUIREMENTS

A. Obtain written permission and required permits from applicable agency prior to start of construction, and submit copies of permits as specified in "Submittals - Quality Control Submittals" above.

## 1.6 PROJECT CONDITIONS

A. Temperature and Seasonal Limitations: Refer to NYSDOT 402-3.01 Temperature and Seasonal Limitations.

1. Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, if the temperature has not been above 35 deg for 12 hours immediately prior to application or if the following minimum surface temperatures are not met.

2. Minimum Surface Temperatures: Comply with NYSDOT Standard Specifications Section 402, table 402-1 – Temperature Requirements.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature in accordance with NYSDOT Standard Specifications Section 685-3.02 – Atmospheric Conditions.

PART 2 - PRODUCTS

2.1 AGGREGATE SUBBASE AND BASE FOR ASPHALT PAVING

A. Refer to Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.

2.2 ASPHALT PAVING MIX AGGREGATES

A. Aggregates for binder and top course: Conform to the requirements of NYSDOT Standard Specification 401-2.02, Aggregates.

2.3 ASPHALT MATERIALS

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes meeting NYSDOT Standard Specifications, Section 402 (70 Series) for each pavement course and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Mixes to be placed at thickness noted on the Drawings.
3. Binder Course (2-in < t < 3-in): NYSDOT No. 402.197904 (Type 3 Binder). Maximum 20% RAP permitted.
4. Binder Course (3-in < t < 5-in): NYSDOT No. 402.257904 (Type 3 Binder). Maximum 20% RAP permitted.
5. Top Course: NYSDOT No. 402.097304 (Type 7.) Maximum 20% RAP permitted.

B. Coatings/Fillers: Comply with New York State Department of Transportation Standard Specification, Section 702 for material designations indicated.

1. Tack Coat: Emulsified asphalt

a. Slow setting type; NYSDOT Designation 702-3601 (SS-1h) or 702-4501 (CSS-1h).
b. Medium setting type; NYSDOT Designation 702-3401 (HFMS-2H) or 702-4301 (CMS-2h)

2. Asphalt Cement Filler: NYSDOT Designation 702-0700.

C. Water: Potable.

2.4 PAVEMENT MARKING PAINT

A. Complying with NYSDOT Standard Specifications:

1. Section 727-09: White and Yellow Solvent Borne Acrylic Permanent Traffic Paint

2. Colors:

a. White for asphalt striping and signage

1) Lane Markings for traffic in the same direction

b. Yellow for traffic markings

1) No parking parent / bus drop-off zones
2) No parking fire lanes
3) Lane Markings for opposing traffic
4) Parking Stalls – Confirm with owner

c. Blue for the following locations:

1) ADA Accessible symbol and associated ADA Accessible striping

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. TM 5626 White Setfast Acrylic Traffic Marking Paint, Sherwin Williams Company, Baltimore, MD
b. TM 5627 Yellow Setfast Acrylic Traffic Marking Paint, Sherwin Williams Company, Baltimore, MD
c. TM 2133 Blue Setfast Latex Traffic Marking Paint, Sherwin Williams Company, Baltimore, MD

B. Pavement Striping Blackout Paint: Opaque, high quality, exterior grade primer compatible with existing asphalt surface and pavement marking paint.

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. TM 5629 Black Setfast Acrylic Traffic Marking Paint, Sherwin Williams Company, Baltimore, MD

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.

2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.

3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

   a. Subsurface preparation shall conform to the appropriate section of NYSS.

4. After rolling, test course with straight edge min. 15 ft. long. Satisfactorily eliminate any depression over 1/4" deep.

5. Proceed with paving only after unsatisfactory conditions have been corrected.

C. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

D. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

## 3.2 SAWCUTTING

A. Saw cut existing pavement perpendicular to the roadway surface in neat lines. If the pavement breaks irregularly along the cut line during removal, saw cut the entire length of pavement again to achieve one uniform, straight, and neat line.

## 3.3 TACK COAT

A. Apply in accordance with NYSDOT Standard Specifications Section 407-3.02.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

B. Manhole and Catch Basin Frames and Grates:

1. Coat surfaces of frames and grates with oil to prevent asphalt adherence to surfaces. Do not tack coat.

## 3.4 PATCHING

A. Hot-Mix Asphalt Pavement:

1. Preparation: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending the minimum distance shown on Drawings into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade. Apply tack coat.

2. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3. Use hot-applied joint sealant to seal new joints. Fill flush with surface of existing pavement and remove excess.

## 3.5 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch.

1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.
3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

## 3.6 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Herbicide Application: Obtain approval of Owner before herbicide notification or application. Notify Owner’s designated pesticide representative and all property neighbors not less than 48 hours in advance of any pesticide application including all herbicides, insecticides and fungicides in accordance with the School Pesticide Neighbor Notification Law, Section 409-h of New York State Education Law and Commissioner's Regulation 155.24.

C. Tack Coat: Apply tack coat.

## 3.7 HOT-MIX ASPHALT PLACING

A. Hot-Mix Asphalt Paving Application: Provide finished surface free from depressions that could collect water. Satisfactorily remove, at Contractor's expense, any depressions over 1/8" when tested with 6-foot straight edge without evidence of patching. Carry all paving to wood stripping, curbing or to location shown on Drawings.

B. Application Over Aggregate Base:

1. Heavy Duty, Auto Duty and Light Duty Asphalt Areas: Apply over aggregate base in 2 courses. Comply with New York State Department of Transportation Standard Specification, Section 401 and Section 402, for asphalt types specified.

C. Placement: Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Spread mix at minimum temperature of 250 deg F.
3. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
4. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

D. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.

E. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

## 3.8 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.

2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.

3. Offset transverse joints, in successive courses, a minimum of 24 inches.

4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.

6. Compact asphalt at joints to a density within 2 percent of specified course density.

7. Use hot-applied joint sealant to seal new joints. Fill flush with surface of existing pavement and remove excess.

## 3.9 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent or greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

## 3.10 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus 1/2 inch, no minus.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.

3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

C. Pavement Surface Drainage: Pavement is to drain to catch basin, swale or other storm drainage control measure as indicated on Drawings or, if not indicated on drawings, to nearest storm drainage control measure.

D. Pavement Remediation: If pavement surface smoothness and drainage requirements above are not met, correct to meet tolerance and performance requirements. If remediation is not acceptable to Architect, removal and replacement of area will be required. Feather and smooth edges of correction measure so that joint is invisible.

## 3.11 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Perform work in accordance with NYSDOT Standard Specifications Section 727-09.

C. Sweep and clean surface to eliminate loose material and dust.

D. Surface must be clean, dry and in sound condition. Remove all oil, dust, grease, dirt, loose rust, and other foreign material to ensure adequate adhesion.

E. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended application conditions (temperature, dew point, humidity) and rates to provide a minimum wet film thickness of 15 mils and minimum dry film thickness of 7.5 mils.

F. Do not apply pavement marking paint to concrete surfaces with concrete sealers or efflorescence. Remove by extended weathering, etching, or abrasive blasting.

## 3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
D. Replace and compact hot-mix asphalt where core tests were taken.
E. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

## 3.13 FLOOD TESTING

A. Flood Tests: Perform flood test in the presence of the Architect using water tank truck to confirm that pavement surface smoothness and surface storm drainage requirements are met.

## 3.14 CLEANING AND DISPOSAL

A. Paver and Equipment Cleaning:

1. Do not clean tools and equipment used for HMA placement on the pavement surface, or near streams, ponds, drainage structures or other areas that are tributaries to waterways.

2. Use an area approved by the Owner's Representative for cleaning all paving equipment and tools.

    a. If possible, remove solid pieces of asphalt by scraping or other mechanical means prior to application of a cleaning agent.

3. If a petroleum product is used for cleaning, contain all liquid products during cleaning operations using tarpaulins, sand pads, pails, or other collection methods to prevent spillage or accidental release.

    a. Use hand sprayers or other similar devices to minimize the amount of petroleum product applied.

4. Properly dispose of sand and collected petroleum products as petroleum contaminated soil at no additional cost to the Owner.

B. Remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION 32 12 16

# SECTION 32 13 13 - CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Sidewalks.
2. Curbs and gutters.
3. Joint Sealant.
4. Concrete Sealer.
5. Curing materials.
6. Joint forming materials.
7. Joint Filler.
8. Sealers
9. Detectable Warning Materials.

B. Related Sections:

1. Section 03 30 00 "Cast-in-Place Concrete for general concrete mix, materials, installation and building-related concrete requirements.

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

B. Refer to Div 03 concrete section for concrete submittal requirements, material certificates, installer qualification data and other required action and informational submittals.

### 1.4 ACTION SUBMITTALS

A. Provide Product Data and Testing Information for each type of product indicated.

1. Forms
2. Form release agent
3. Sealer
4. Joint Sealant
5. Curing Compound
6. Expansion Joint Material
7. Expansion Joint Forming System
8. Detectable Warning Materials

1.5 SHOP DRAWINGS

A. Jointing Plan: Provide shop drawing showing concrete joint layout, specifically indicating the locations of expansion, tooled and control joints.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer. (Refer to Div 03 concrete section for requirements.)

1.7 QUALITY ASSURANCE

A. For Installer and Manufacturer requirements, refer to Div 03 concrete section**.**

B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship in the location and of the size indicated where directed by Architect and not less than 96 inches by 96 inches.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

3. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 Refer to Div 03 concrete section for products, unless noted below.

2.2 FORMS

A. Form Materials: Metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

## 2.3 CONCRETE MATERIALS

A. Refer to Div 03 concrete section for cementitious material, aggregates, admixtures, and other concrete materials.

## 2.4 FIBER REINFORCEMENT

A. Refer to Div 03 concrete section for fiber reinforcement materials.

## 2.5 CURING MATERIALS

A. Standard Concrete Curing Compound: Clear, Waterborne, Membrane-Forming Curing Compound in accordance with ASTM C 309, Type 1-D, Class B, dissipating, with fugitive dye. Minimum 2-coats required.

## 2.6 SEALER

A. Standard Concrete Sealer: Penetrating, Silane Sealer: Single component, 40% silane, waterbased slab sealer that forms chemical bond to the concrete. VOC compliant.

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. BASF Construction Chemicals; MasterProtect H 400.
    b. Chem Masters; Aquanil Plus 40.
    c. Dayton Superior Corporation; Weather Worker 40% J29WB.

## 2.7 JOINT SEALANT

A. Joint Sealant: Two-part, elastomeric polyurethane or polysulfide-based pourable self-leveling joint sealant complying with ASTM C 920, Type M, Grade P, Class 25, NT and CRD-C-506, Type 1, Classes A & B.

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. BASF Building Systems; Sonolastic SL 2.

        1) Color for uncolored concrete: Limestone.

    b. W.R. Meadows, Inc.; Deck-O-Seal Sealant.

        1) Color for uncolored concrete: Stone Gray.

## 2.8 EXPANSION JOINT MATERIALS

A. Expansion/Isolation-Joint-Filler Strips: ½-inch rigid, extruded polystyrene insulation (at exterior walls) ASTM D 1751; asphalt-saturated cellulosic fiber, or ASTM D 1752.

B. Plastic Expansion Joint Forming System ("Zip-Strip"): Plastic joint form plus cap.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following: (inserted space)

a. W.R. Meadows, Inc.; Snap-Cap.

## 2.9 DETECTABLE WARNING MATERIALS

A. Ductile iron detectable warning surface plates - for handicap accessible concrete curb ramps: Ductile iron, permanently embedded, wear and corrosion resistant 18-inch/24-inch/30-inch x 24-inch ductile iron plates with raised truncated domes complying with ADA and the NYS Building Code, having a skid resistance coefficient of friction greater than 0.8.

1. Physical Properties:

a. Slip Resistance ..... 1.10 Dry/1.06 Wet per ASTM C-1028
b. Wear Resistance ..... 7333 per ASTM C-501-84
c. Impact Resistance..... > 238 Newtons per ASTM D-1709
d. Bond Strength Adhesion to Concrete ..... > 5000 lbs per ASTM D-482
e. Tensile Strength..... > 35000 lbs per ASTM A-48
f. Design Compliance ..... Full Compliance with ADAAG / DOT

2. Hardware:

a. Manufacturer approved stainless steel hardware for bolting plates together

3. Coating:

a. Shop-dip applied black asphaltic coating.

4. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. East Jordan Iron Works, Inc. (EJIW): Duralast Cast Iron Detectable Warning Plates.

## 2.10 CONCRETE MIXTURES

A. Refer to Div 03 concrete section for concrete mixtures.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete paving in accordance with Section 31 20 00 “Earth Moving”. Identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction and repeat in perpendicular direction.

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

D. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

### 3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

### 3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

### 3.4 STEEL REINFORCEMENT

A. Refer to Div 03 concrete section for steel reinforcement.

### 3.5 JOINTS

A. General: Form construction, expansion/isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

1. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.

2. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Expansion / Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 30 feet maximum unless otherwise indicated.

2. Extend joint fillers full width and depth of joint.

3. Plastic Expansion Joint Forming System ("Zip Strip"). Install so that cap of channel is flush with surrounding concrete pavement. Install per manufacturer's installation instructions. Remove plastic cap after concrete is cured.

4. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.

5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

D. Control / Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving unless otherwise noted:

1. Tooled / Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.

2. Tooled / Grooved and Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks. Sawed joints without tooling are not allowed.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

## 3.6 CONCRETE PLACEMENT

A. Refer to Div 03 concrete section for concrete placement information.

B. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

C. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

D. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

E. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

F. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301, (4.3.2.1 Slump Adjustment).

1. With each concrete mixture submittal, indicate amounts of mixing water to be withheld for later addition at Project site.

2. Water added must not increase the water-cement ratio past the approved mix design ratio.

3. Add additional water reducer or plasticizer to mix instead of adding water to achieve flowable, workable concrete. Do not add water to concrete after adding these admixtures to mixture.

4. Do not add water after truck is more than half empty.

G. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

H. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement dowels and joint devices.

I. Screed paving surface with a straightedge and strike off.

J. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

K. Machine-Placed Curbs and Gutters: Allowed only upon Architect approval. Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

L. Slip-Form Paving: Allowed only upon Architect approval. Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

M. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

N. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

## 3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

## 3.8 DETECTABLE WARNINGS

A. Cast Iron Detectable Warning Surface Plates:

1. Connection: Fasten plates together with stainless steel bolts per manufacturer's torque requirements.

2. Setting Plates: Set cast iron detectable warning plates into wet concrete in accordance with ADAAG (American Disabilities Act and Accessibility Guidelines). Tamp plates thoroughly with rubber mallet until concrete seeps through vent holes.

3. Clean off excess concrete from the plate(s) and adjust adjacent concrete to be flush with plates. Finish concrete around plates to match surrounding concrete.

## 3.9 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 and 305R for hot-weather protection during curing.

B. Slabs: Protect slabs within building from precipitation accumulation. Immediately remove water, snow or ice from surface of slabs within building regardless if source is from precipitation, construction activities, etc.

C. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Formed Surfaces: Cure formed concrete surfaces, including supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

E. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

F. Cure concrete according to ACI 308.1:

1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

G. Apply penetrating, silicane sealer per manufacturer's instructions.

## 3.10 FIELD QUALITY CONTROL

A. Refer to Div 03 concrete section for field quality control information.

1. Contractor Requirements:

a. Provide access to concrete construction for representatives of testing agency employed by Owner to perform concrete testing.
b. Notify Architect at least four days in advance of each concrete placement to allow notification of Owner's testing agency.

## 3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

# SECTION 32 14 00 – UNIT PAVERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes

1. Interlocking concrete unit pavers
2. Setting bed sand
3. Jointing Sand
4. Grout and Mortar
5. Paver sealant
6. Paver edging

B. Related Sections

1. Section 31 20 00 – Earth Moving

### 1.3 SUBMITTALS

A. Comply with requirements of Section 01 33 00 - Submittals and as modified below.

B. Product Data: Submit manufacturer's technical data for each manufactured product, including certification that each product complies with specified requirements.

C. Samples

1. Concrete Paving Units: Submit samples demonstrating manufacturer’s full range of colors and textures available in products complying with specified requirements. Furnish samples fabricated from actual units or sections of units. Submit samples consisting of 5 individual units for each color and texture. Include in each set, maximum variation expected in finished construction.

2. Grout and Mortar: Submit cured samples of each type of colored grout and mortar, showing the range of color that can be expected in the finished work.

D. Sample Panel

1. Provide onsite formed panel demonstrating unit paver layout, jointing and finishing – 10’x10’ minimum.

E. Quality Control Submittals

1. Qualifications Certification: Submit written certification or similar documentation signed by applicable subcontractor, Prime Contractor and manufacturer (where applicable) indicating compliance with applicable “Qualifications” requirements specified below in “Quality Assurance” article.

2. Installer Experience Listing: Submit list of five (minimum) completed projects using products proposed for this Project or similar, including owner’s contact and telephone number for each project, demonstrating compliance with applicable “Qualifications” requirements specified below in “Quality Assurance” article. Provide proof of certification as ICPI Certified Instructor.

## 1.4 QUALITY ASSURANCE

A. Installer Qualifications: Firm with not less than 5 years of successful experience in the required types of paving application. Installer to be an ICPI Certified Instructor.

B. Field Sample/Mockup: Prior to installation of paving work, fabricate sample panel using specified materials, pattern and joint treatment, including special features for expansion joints and continuous construction.

C. Construct sample panel at Site, as directed, in full thickness and approximately 3 ft. x 3 ft., unless otherwise indicated on Drawings. Provide range of color, texture and workmanship expected in completed construction. Obtain Architect's acceptance of visual qualities of panel before start of paving construction. Retain panel during construction as standard for evaluating completed paving installation. Do not move or destroy sample panel until paving installation is completed and accepted.

D. Provide sample panel for each type of concrete paving unit required.

## 1.5 DELIVERY, STORAGE AND HANDLING

A. Protect materials during storage and construction against wetting by rain, snow or ground water and against soilage or intermixture with earth or other types of materials.

B. Protect Portland cement from deterioration by moisture and temperature. Store in dry location or in waterproof container. Keep container tightly closed and away from open flame. Protect liquid components from freezing.

## 1.6 PROJECT/SITE CONDITIONS

A. Cold Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build frozen subgrade or setting beds. Remove and replace masonry work damaged by frost or freezing.

B. Weather Limitations: Protect unit pavers against freezing when atmospheric temperature is 40 degrees F. (4 degrees C) and falling. Heat materials and provide temporary protection of completed portions of paving work. Comply with requirements of BIA Technical Notes, No. 1A, "Cold Weather Masonry Construction - Construction and Protection Recommendations."

C. Hot Weather Requirements: Protect unit pavers in hot weather to prevent excessive evaporation of setting beds and grout. Provide artificial shade, wind breaks and use cooled materials, as required.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURER

A. For convenience, details and specifications have been based on products by Unilock, Inc., Buffalo, New York, www.Unilock.com.

### 2.2 MATERIALS

A. Concrete Unit Pavers: ASTM C936. Similar to "Hollandstone" by Unilock.

1. Minimum Average Compressive Strength: 8,500 psi.
2. Maximum Absorption: 5%.
3. Freeze-Thaw Resistance: 50 freeze-thaw cycles.
4. Size: 4" x 8" x 2.375"
5. Color: As selected by Architect from manufacturer’s full range of colors.

B. Concrete Unit Pavers: ASTM C936. Similar to "Double Holland" by Unilock.

1. Minimum Average Compressive Strength: 8,500 psi.
2. Maximum Absorption: 5%.
3. Freeze-Thaw Resistance: 50 freeze-thaw cycles.
4. Size: 8" x 8" x 2.375"
5. Color: As selected by Architect from manufacturer’s full range of colors.

C. Setting Bed Sand:

1. Clean, non-plastic sand free from deleterious or foreign matter. Natural or manufactured from crushed rock. Must comply with the grading requirements below.

2. "Concrete" sand meeting following gradation requirements:

| | SIEVE DESIGNATION | % BY WEIGHT PASSING SQUARE MESH SIEVE |
|---|---|---|
| a. | 3/8 in. (9.5 mm) | 100 |
| b. | No. 4 (4.75 mm) | 95 to 100 |
| c. | No. 8 (2.36 mm) | 85 to 100 |
| d. | No. 16 (1.18 mm) | 50 to 85 |
| e. | No. 30 (600 µm) | 25 to 60 |

f. No. 50 (300 µm) ..... 10 to 30
g. No. 100 (150 µm) ..... 2 to 10

D. Crushed Stone Base – Clean crushed stone meeting following gradation requirements:

| | SIEVE DESIGNATION | % BY WEIGHT PASSING SQUARE MESH SIEVE |
|---|---|---|
| a. | 3/4" | 100% |
| b. | 1/2" | 80% to 100% |
| c. | No. 4 | 45% to 65% |
| d. | No. 10 | 35% to 50% |
| e. | No. 40 | 12% to 26% |
| f. | No. 200 | 0% to 8% |

E. Jointing Sand:

1. Clean, non-plastic sand free from deleterious or foreign matter purchased in bags versus in bulk. Natural or manufactured from crushed rock. Must comply with the grading requirements below. Setting bed sand should not be used for jointing sand.

| Sieve Size | Natural Sand | Manufactured Sand |
|---|---|---|
| No. 4 (4.75 mm) | 100 | 100 |
| No. 8 (2.36 mm) | 95 - 100 | 95 to 100 |
| No. 16 (1.18 mm) | 70 - 100 | 70 to 100 |
| No. 30 (600 µm) | 40 - 75 | 40 to 75 |
| No. 50 (300 µm) | 10 - 35 | 20 to 40 |
| No. 100 (150 µm) | 2 - 15 | 10 to 25 |
| No. 200 (75 µm) | 0 | 0 to 10 |

F. Polymer Jointing Sand:

1. Mix of graded sand and polymer binder, suitable for filling narrow or wide joints.
2. Similar to “Polymeric Sand”, available through Unilock.

G. Filter Fabric: Similar to “500X@ by Mirafi, Inc.; Charlotte, North Carolina.

H. Paver Edging:

1. PVC plastic edging manufactured specifically for unit pavers with spikes or other anchoring system.
2. Similar to “Spikedge”, available through Unilock.

I. Paver Sealant:

1. Clear microporous acrylic emulsion specifically formulated to seal concrete unit pavers and bonds joints.
2. Similar to “Unilock Joint Sand Stabilizer and Paver Sealer”.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verification of Conditions: Prior to start of work, carefully inspect in coordination with installer of materials and components specified in this Section installed construction of all trades and verify construction is sufficiently complete enough to commence unit paver installation. In event of discrepancies, immediately contact affected Prime Contractors and Architect in writing. Do not proceed with paver installation in areas of discrepancy until all such discrepancies have been resolved.

1. Prime Contractor to submit to Architect written confirmation from applicable installer that confirms conditions as acceptable to ensure proper and timely installation and to ensure requirements for applicable warranty or guarantee can be satisfied. Failure to submit written confirmation and subsequent installation will be assumed to indicate conditions are acceptable to installer.

### 3.2 INSTALLATION

A. Granular Base: Compact undisturbed subgrade to 95% density. Place ¾” gravel from compacted subgrade to within 5" of setting bed and compact base material in maximum 4" lifts to 95% density at lines and elevations shown on Drawings.

B. Sand Setting Bed: Spread and compact sand evenly to lines and elevations shown and screed.

C. Paving Units

1. Do not use paving units with excessive chips, cracks, voids, discoloration or other defects which might be visible or cause staining in finished work.

2. Cut paving units with motor-driven saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern shown and to fit adjoining work neatly. Use full units without cutting.

3. Place paving units carefully by and in straight course maintaining accurate alignment and uniform top surface. Protect newly laid paving units with panels of plywood on which workers stand. Advance protective panels as installation progresses, maintaining protection in areas subject to continued movement of materials and equipment and avoiding creating depressions or disrupting alignment of paving units. If additional leveling of paving is required before treating joints, roll with power roller after sufficient heat has built up in surface from several days of hot weather.

4. Color Blending: Disperse and blend variations in color so that there are not “patches” of different colors. To assist in color dispersement, install paving units from a minimum of three bundles of pavers, simultaneously drawing the paver vertically rather than horizontally.

5. Joints between the pavers on average shall be between 1/16 in. and 1/8 in. (2 mm to 4 mm) wide. In order to maintain the desired pattern, joint spacing must be consistent. This spacing must also be provided for the first row abutting the edge restraint.

D. Joint Treatment:

1. Spread jointing sand over dry pavement after initial compaction has been completed. Broom to fill joints completely.
2. Sweep the surface clean before compaction.
3. Recompact twice (min.) with plate compactor.
4. Broom fill joints, sweep and recompact again. Moisten as required by manufacturer installation instructions.
5. Thoroughly remove excess sand from pavement surface.
6. Install polymer sand in accordance with manufacturer's installation instructions.

E. Tolerances: Maintain surface plane for finished paving unit not exceeding tolerance of 1/8" in 10 ft. when tested with 10 ft. straight edge. Provide hand tight joints reading from 0" to max. 1/4".

F. Paver Edging: Edge restraints shall be used along all unrestrained paver edges that are not supported by concrete curbing, building wall, planter wall or other stable vertical surface.

1. Supported paver edging on a minimum of 6 in. aggregate base.
2. Paver edging is to be butted up tightly to paver edge without sand, mortar or other debris between paver and edging.
3. Anchor edging with spikes or other system as recommended by manufacturer.
4. Install paver edging in accordance with manufacturer's installation instructions.

G. Paver Sealant:

1. Thoroughly clean all pavers with manufacturer recommended system before applying sealer.
2. Apply paver sealer as soon as possible after installation to avoid efflorescence before pavers are sealed.
3. Apply sealer uniformly to dry pavers in application amounts and under conditions recommended by manufacturer.
4. Sealer should be absorbed into pavers at a minimum of 1" depth.
5. Saturate joints thoroughly.
6. Avoid over-spray or excess sealer spreading onto adjacent surfaces such as concrete paving, asphalt paving, lawn, etc.
7. Apply paver sealant in accordance with manufacturer's installation instructions.

## 3.3 ADJUSTING, CLEANING AND PROTECTION

A. Remove and replace loose, chipped, broken, stained or otherwise damaged paving units or units not matching adjoining units. Provide new units to match adjoining units and install in same manner as original units with same joint treatment to eliminate evidence or replacement.

B. Remove excess sand or mortar/grout from exposed paver surfaces, wash and scrub clean.

C. Protect unit paving installations from deterioration, discoloration or damage during subsequent construction and until acceptance in compliance with recommendations of installer and paving unit manufacturer.

END OF SECTION 32 14 00

# SECTION 32 92 00 - TURF AND GRASSES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Seeding.
2. Sodding.
3. Hydroseeding
4. Turf planting soil.
5. Turf planting soil amendments and fertilizers.
6. Turf renovation.
7. Turf.
8. Turf maintenance.

### 1.3 SUBMITTALS, GENERAL

A. General: Submit all action submittals and informational submittals required by this Section concurrently.

### 1.4 ACTION SUBMITTALS

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

1. Seed.
2. Sod.
3. Fertilizer.
4. Compost.
5. Imported Topsoil

B. Samples for Verification: For the following products, in sizes or quantities indicated below:

1. Imported Topsoil: One-half gallon by volume of material in sturdy container of each type of topsoil, naming source for each material.

C. Warranty: Sample of special warranty.

## 1.5 INFORMATIONAL SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, 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.

B. Qualification Data: For qualified landscape Installer.

C. Product Certificates: For soil amendments and fertilizers, from manufacturer.

D. Material Test Reports: For imported topsoil.

1. Before delivery of imported topsoil, submit written statement giving location of properties from which topsoil is to be obtained, names and addresses of property owners, topsoil nutritional analysis report per requirements below, depth to be stripped, and any crops grown during the previous 5 years.

## 1.6 CLOSEOUT SUBMITTALS

A. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

B. Warranty: Executed special warranty.

## 1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.

2. Turf Installer: Engage an experienced turf installation firm to perform work of this Section. Firm shall have completed work similar in material, design, and extent to that indicated for this Project with a record of successful in-service performance.

B. Soil Nutritional Analysis Report for Imported Topsoil: Furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; available nutrients; deleterious material; pH and recommendations to obtain optimal pH factor; mineral and nutrient content of the soil.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

## 1.9 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

1. Spring Planting: March 15 to May 15.
2. Fall Planting: August 15 to September 15.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

## 1.10 SEQUENCING AND REVIEW

A. Notify Architect no fewer than 48 hours in advance of proposed seeding and sodding to allow review of topsoil finish grading.

B. Do not proceed with seeding and sodding without Architect's written permission.

1. Architect’s written permission does not alleviate Contractor from conforming to the required grades indicated on Drawings.

## 1.11 MAINTENANCE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, as determined by the Architect, but for not less than the following periods:

1. Seeded and Sodded Turf: Five (5) documented mowings.

    a. Document mowings in writing via fax or email to Owner and Architect on the day each mowing is performed. Failure of notification may subject Contractor to further mowings at no additional cost to Owner.

2. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

B. Water: Provide all water required to properly irrigate temporary, permanent, and renovated turf areas. Include all facilities including, but not limited to, hoses, sprinklers, water cannons and reels, as long as it takes to establish and maintain turf. When adequate water supply or pressure is not available, supply water from offsite, including trucking.

## 1.12 WARRANTY

A. Special Warranty: Installer agrees to repair or replace turf that fails in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.

2. Warranty Period:

    a. Turf: 12 months, after acceptable turf is established, as determined by the Architect.

3. Include the following remedial actions as a minimum:

    a. Immediately remove dead turf and replace unless required to plant in the succeeding planting season.
    b. Replace with seed or sod as originally specified.

B. Provide extended warranty for period equal to original warranty period, for replaced turf material.

# PART 2 - PRODUCTS

## 2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Varieties: Premier varieties of Kentucky bluegrass, perennial ryegrass, tall fescue and fine fescue with a mean ranking of 6.0 or higher on the National Turfgrass Evaluation Program (NTEP) current list of tested varieties for the Northeast United States.

C. Seed Blends: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

1. General Lawn Mixture - Tall Fescue/Kentucky Bluegrass Blend: Proportioned by weight as follows:

   a. 85 percent tall fescue (Festuca arundinacea).
   b. 15 percent Kentucky bluegrass (Poa pratensis).

2. General Lawn Mixture - Kentucky Bluegrass Blend: Proportioned by weight as follows:

   a. 85 percent 1/3 equal mixture of three Kentucky bluegrass (Poa pratensis) varieties.
   b. 15 percent fine fescue (Fescue rubra).

3. General Lawn Sun/Shade Mixture: Proportioned by weight as follows:

   a. 75 percent 1/3 equal mixture of three Kentucky bluegrass (Poa pratensis) varieties.
   b. 25 percent fine fescue (Fescue rubra).

4. Athletic Field Blend (Kentucky bluegrass): Proportioned by weight as follows:

   a. 90 percent 1/3 equal mixture of three Kentucky bluegrass (Poa pratensis) varieties.
   b. 10 percent fine fescue (Fescue rubra).

5. Athletic Field Blend (Tall fescue/Kentucky Bluegrass): Proportioned by weight as follows:

   a. 75 percent tall fescue.
   b. 25 percent Kentucky bluegrass (Poa pratensis).

## 2.2 TURFGRASS SOD

A. Turfgrass Sod: Gold Tag certified premium quality seed, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.

B. Varieties: Premier varieties of Kentucky bluegrass and fescue with a mean ranking of 6.0 or higher on the National Turfgrass Evaluation Program (NTEP) current list of tested varieties for the Northeast United States.

C. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

1. Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three varieties.
2. Sun and Partial Shade: Kentucky bluegrass (Poa pratensis) and fescue blend.

D. Moisture Content: Do not harvest or transplant sod when moisture content (excessively dry or wet) may adversely affect its survival.

E. Height: Mow sod before stripping to a height of one inch to 2-1/2 inches.

F. Thickness of Cut: Machine cut sod at a uniform soil thickness of 5/8-inch, plus or minus 1/4-inch, at time of cutting. Exclude top growth and thatch from measurement for thickness.

G. Pad Size: Cut to supplier's standard width and length. Maximum allowable deviation from standard widths of 1/2-inch. Maximum allowable deviation from standard length of 5 percent. Broken pads and torn or uneven ends not acceptable.

H. "Big Roll" Form: Sod cut a minimum 42 inches wide and 100 feet long, machine cut at uniform soil thickness of 0.75-inch, measured to exclude top growth and thatch.

I. Strength of Sod Sections: Standard size sections of strong enough to support own weight and retain size and shape when suspended vertically from a firm grasp on the upper 10 percent of the section.

J. Thatch: Up to 1/2 inch height (uncompressed) allowable.

K. 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. CY Farms/Batavia Turf.
2. Lakeside Sod Supply Co., Inc.

## 2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through No. 8 sieve and a minimum of 75 percent passing through No. 60 sieve.
2. Provide lime in form of ground dolomitic limestone.

B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 sieve and a maximum of 10 percent passing through No. 40 sieve.

## 2.4 ORGANIC COMPOST

A. Compost: Organic product manufactured through the controlled aerobic, biological decomposition of biodegradable materials which involves mesophilic and thermophilic temperatures to reduce weed seeds and stabilize carbon content. Manufacturing facility is to be registered and/or permitted by New York State Department of Environmental Conservation and is to comply with their requirements.

B. Compost Requirements:

| Parameters | Units of Measure | Range | Analysis Method |
|---|---|---|---|
| pH | pH units | 5.8-7.8 | TMECC 04.11-A |
| Soluble Salts Concentration (electrical conductivity) | dS/m (mmhos/cm) | Maximum 6 | TMECC 04.10-A |
| Moisture Content | %, wet weight basis | 20-50 | TMECC 03.09-A |
| Organic Matter Content | %, dry weight basis | Minimum 60 | TMECC 05.07-A |
| Particle Size | % passing a selected mesh size, dry weight basis | 97-100% Passing 3/8" | TMECC 02.02-B or ASTM D 2977 |
| C:N Ratio | Ratio, dry weight basis | 5:1 – 30:1 | TMECC 05.02-A |
| Physical Contaminants (man-made inerts) | %, dry weight basis | <.50 | TMECC 03.08 |

C. Mix with existing and imported topsoils in ratio designated in "Turf Planting Soil" Article below. Compost must be provided for both existing and imported topsoil, with the exception of topsoil with 10% of organic content and above.

D. Basis-of-Design Product: Subject to compliance with requirements, provide Agresource, Inc.; Agresoil Compost, or comparable product by the following:

1. Naturcycle Compost, Naturcycle LLC
2. WeCare Compost, WeCare Organics
3. Sustane Concentrated Compost 2-6-3, Sustane Natural Fertilizer, Inc.
4. Agresource, Inc. - Agresoil Compost

## 2.5 FERTILIZERS

A. 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, unless otherwise indicated:

1. Spring Fertilization: 10 percent nitrogen, 6 percent available phosphorous, and 2 percent water-soluble potash (10-6-4).

2. Fall Fertilization: 5 percent nitrogen, 10 percent available phosphorous, and 5 percent water-soluble potash (5-10-5).

3. Final Fertilization:

    a. Spring: Granular slow release fertilizer with high nitrogen (38 percent), Uramite or other Architect-approved material.
    b. Fall: “Fall Fertilization” composition above.

4. Follow requirements regarding fertilization recommended in soil reports from a qualified soil-testing laboratory.

## 2.6 TURF PLANTING SOILS

A. General: Provide turf planting soil consisting of existing and/or imported topsoil with amendments and fertilizers noted in this Section.

1. Where quantities of existing topsoil are insufficient to provide 6 inch depth turf planting soil, supplement with imported topsoil, at no additional cost to Owner.

B. Topsoil Requirements: Free of subsoil, stones 1 inch or larger in any dimension, dense material, hardpan, slag, clay, cinders, sod, roots, sticks, poison ivy, crabgrass, cough grass, noxious weeds, and foreign matter, including but not limited to glass, screws, asbestos, toxins, hazardous wastes, petroleum product contamination, lead and chemicals (such as atrizene and muriatic acid) that may be injurious to humans, animals and plant materials.

1. Topsoil (Existing and Imported) to comply with the following:

    a. Organic Matter Content: Not more than 10 percent.
    b. Corrected to pH Value: 6.5 to 7.5 on that portion passing 1/4-inch sieve.
    c. Soluble Salt Content: Not to exceed 500 parts per million.
    d. No more than 60 percent of material passing #100 mesh shall consist of clay as determined by Bouyoucous hydrometer or by decantation method.

2. Existing Topsoil: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil.

3. Imported Topsoil: Imported topsoil obtained from local sources or from areas having similar soil characteristics as Project site. Obtain topsoil displaced from naturally well-drained sites where topsoil occurs at least 6 inches deep; do not obtain from agricultural land, bogs or marshes.

a. Additional Properties of Imported Topsoil or Manufactured Topsoil: Screened and free of stones 1 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass; not infested with nematodes, grubs, other pests, pest eggs, or other undesirable organisms and disease-causing plant pathogens; friable and with sufficient structure to give good tilth and aeration. Continuous, air-filled, pore-space content on a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Soil shall have a field capacity of at least 15 percent on a dry weight basis.

b. Soil Analysis Report: Provide soil analysis and report to demonstrate that the above requirements are being met and to identify if nutritional amendments are needed.

c. Soil Analysis Recommendations: Provide amendments recommended in the soil analysis report, as approved by Architect.

d. Mechanically screen imported topsoil to conform to following gradations:

| Sieve Designation | Percent Passing |
|---|---|
| 1 inch | 100 |
| 1/4 inch | 97-100 |
| #200 | 20-65 of the 1/4-inch sieve |

C. Required Amendments: Mix existing and imported topsoil with the following soil amendments in the following quantities to produce planting soil:

1. Organic Compost:

a. Thoroughly till ½" depth of organic compost into upper 4" of soil.] or [Ratio of Loose Compost to Surface Soil per 1,000 Sq. Ft.: 5 parts soil to 1 part compost.

b. Regardless of topsoil organic content, add organic compost to all turf planting soils, including topsoils placed on slopes and in stormwater basins, swales and biofiltration areas.

2. pH Adjustment: Apply approved calcium or sulfur compounds to correct pH level to be between 6.5 and 7.5.

3. Provide fertilizer per "Fertilizer" Article above.

## 2.7 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

## 2.8 HYDROSEEDING MATERIALS

A. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

## 2.9 EROSION-CONTROL MATERIALS

A. Refer to Section 31 25 00 “Erosion and Sedimentation Controls.”

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting 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. Proceed with installation only after unsatisfactory conditions have been corrected.

C. 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 Architect and replace with new planting soil.

D. Beginning installation constitutes Contractor’s acceptance of substrates and conditions.

## 3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray. Protect grade stakes set by others until directed to remove them.

## 3.3 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Thoroughly blend topsoil with soil amendments and fertilizer.

a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
b. If liming is required, mix lime with dry soil before mixing fertilizer.

2. Spread planting soil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

a. Spread approximately 1/3 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 2 inches of subgrade. Spread remainder of planting soil.
b. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:

1. Cut neat line between existing turf to remain and new turf.

2. Remove existing grass, vegetation, and turf. Do not mix into surface soil.

3. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.

4. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.

5. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Architect's written permission; restore planting areas if topsoil finish grading is eroded or otherwise disturbed after finish grading.

## 3.4 SEEDING

A. Timing: Provide seeding within planting times indicated.

1. Seed at earliest possible date to achieve mature turf prior to Owner occupancy.

B. Sow seed with Brillion spreader or similar seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in three passes: second pass at 90 degrees to the first, third pass at 45 degrees to second.

1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

C. Sow seed at a total rate of 6 lb/1,000 sq. ft.

D. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.

E. Protect seeded areas with slopes not exceeding 1:4 as follows:

1. In small areas adjacent to buildings, at parking islands and narrow strips of seeding along paving, spread straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment. Avoid areas of thick mulch that will prevent seed determination.

F. Water newly planted areas and keep moist until new turf is established.

## 3.5 HYDROSEEDING

A. Prior Permission: Request permission of Architect for hydroseeding. Do not hydroseed without prior written permission of the Architect. Equipment and materials must be submitted and approved before permission to hydroseed will be given.

B. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.

2. Apply slurry uniformly to all areas to be seeded in a two-step process.

   a. Apply first slurry coat containing mulch and seed at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

   b. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1,000 lb/acre. For slopes greater than 10 percent, apply second coat at 1,500 lb/acre.

3. When hydromulching, avoid overspray on buildings, pavements, signs and other site features. If overspray occurs, clean mulch from all surfaces.

C. Water newly planted areas and keep moist until new turf is established.

## 3.6 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

   1. Lay sod across angle of slopes exceeding 1:3.

   2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

D. Water newly sodded areas and keep moist until new turf is established.

## 3.7 TURF RENOVATION

A. Renovate existing turf indicated on Drawings, turf areas anticipated to be disturbed as part of Project, and areas damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

   1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   2. Install new planting soil as required.

B. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

C. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.

D. Mow, dethatch, core aerate to a minimum depth of 4 inches, and rake existing turf.

E. Remove weeds before seeding.

F. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

G. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.

H. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.

I. Apply seed and protect with straw mulch as required for new turf.

J. Water newly planted areas and keep moist until new turf is established.

## 3.8 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. Use hand weeding to control weeds. Schedule weedings throughout the year to maintain turf as free of weeds as possible.

B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.

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.

2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.

C. Mow turf when new growth reaches 3.75-4.5 inches in height.. Repeat mowing to maintain specified height once per week or as needed to ensure the maximum height does not exceed 4.5 inches between mowing 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 turf to a height of 2-1/2 to 3 inches.
2. Neatly trim edges and hand clip where necessary.
3. Immediately after each mowing (same day), carefully remove excess clippings to prevent damage to turf.

D. Turf Post fertilization: Apply fertilizer after initial mowing and when grass is dry.

## 3.9 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.

2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

C. Warranty period does not begin until satisfactory turf is established, as determined by the Architect.

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.

## 3.10 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 92 00

# SECTION 33 41 00 - STORM UTILITY DRAINAGE PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Non-pressure transition couplings.
3. Cleanouts.
4. Drains.
5. Frames and grates/lids
6. Catch basins.
7. Stormwater Manholes.
8. Dry wells.

B. Related Sections:

1. Section 01 78 39 “Project Record Documents”
2. Section 31 20 00 "Earth Moving"

### 1.3 SUBMITTALS

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

B. Shop Drawings:

1. Stormwater Manholes: Include plans, elevations, sections, details, frames, covers, and grates.
2. Catch basins. Include plans, elevations, sections, details, frames, covers, and grates.
3. Dry wells. Include plans, elevations, sections, details, frames, covers, and grates.

C. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

D. Quality Control Submittals

1. Qualifications Certification: Submit written certification or similar documentation signed by applicable subcontractor, Prime Contractor and manufacturer (where applicable) indicating compliance with applicable “Qualifications” requirements specified below in “Quality Assurance” article.

2. Installer Experience Listing: Submit list of completed projects using products proposed for this Project, including owner's contact and telephone number for each project, demonstrating compliance with applicable "Qualifications" requirements specified below in "Quality Assurance" article.

## 1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Perform work, including shoring, in compliance with the applicable requirements of governing authorities having jurisdiction.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
B. Protect pipe, pipe fittings, and seals from dirt and damage.
C. Handle stormwater manholes according to manufacturer's written rigging instructions.
D. Handle catch basins according to manufacturer's written rigging instructions.

## 1.6 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

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

# PART 2 - PRODUCTS

## 2.1 SOLID DOUBLE WALL HDPE SMOOTH INTERIOR PIPE:

A. Interior Diameter, 4" to 36": Corrugated polyethylene circular pipe with an integrally formed smooth interior complying with the following specifications:

1. Applicable Standards:

a. 4 inch to 10 inch pipe: AASHTO M 252-Type S or SP
b. 12 inch to 36 inch pipe: AASHTO M294-Type S or SP

2. Mannings "n" Value: 0.012.

3. ASTM D3034 for maximum allowable deflection.

4. Fittings: Meet performance requirements of ASTM D 3034 and ASTM F 1336. Gaskets to comply with ASTM F477.

5. Manufacturer: Similar to "N-12 Smooth Interior Pipe" by Advanced Drainage Systems, Inc.; London, Ohio.

## 2.2 NONPRESSURE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

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. Dallas Specialty & Mfg. Co.
b. Fernco Inc.
c. Mission Rubber Company; a division of MCP Industries, Inc.
d. NDS Inc.
e. Plastic Oddities; a division of Diverse Corporate Technologies, Inc.

2. Description: Elastomeric sleeve with corrosion-resistant-metal tension band and tightening mechanism on each end.

## 2.3 CLEANOUTS

A. Cast-Iron Cleanouts:

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. Josam Company.
b. Smith, Jay R. Mfg. Co.
c. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

2. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover with vandal proof screws. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

3. Top-Loading Classification(s): Heavy Duty.

4. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

## 2.4 DRAINS

A. Inline Drains:

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. Nyloplast by Advance Drainage Systems, Inc.

2. Description: Precast PVC Inlet with cast or ductile iron body with anchor flange and round grate in diameter shown on Drawings. Include watertight pipe adapters of sizes indicated.

   a. Joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals

   b. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron and ASTM A-48-83 class 30B for 12” and 15” cast iron frames. Grates shall be provided painted black

3. Backfill Material

   a. The backfill material shall be crushed stone or other granular material meeting the requirements of Structure Bedding as defined in Section 31 20 00 Earth Moving.
   b. The drainage inlets shall be bedded and back-filled uniformly in accordance with ASTM D2321.

4. Top-Loading Classification(s): Heavy Duty H20 Traffic Loading.

## 2.5 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4,000 psi minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Ballast and Pipe Supports: Portland cement design mix, 3,000 psi minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

## 2.6 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening.
B. Gutter Inlets: Made with horizontal gutter opening. Include heavy-duty frames and grates.
C. Combination Inlets: Made with vertical curb and horizontal gutter openings. Include heavy-duty frames and grates.

## 2.7 CATCH BASINS

A. Inside Dimension: 30-inch by 30 inch clear inside area, unless otherwise indicated.

B. Description: ASTM C 913, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

C. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.

D. Riser Sections: 4-inch minimum thickness, Length, Width and Depth as indicated.

E. Top Section: Flat-slab-top type is indicated.

F. Joint Sealant: ASTM C 990, bitumen or butyl rubber.

G. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.

H. Grade Rings: Include two or three reinforced-concrete rings, of 6 to 9-inch total thickness, that match the frame and grate, and height as required to adjust manhole frame and cover to indicated elevation and slope.

I. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

## 2.8 CATCH BASIN FRAMES AND GRATES

A. Heavy Duty Ductile Iron Frame and Grate:

1. Description: Heavy-duty 24-in by 24-in (nominal clear opening) ductile iron frame and grate.

2. Material Requirements:

a. Material: ASTM A 536, Grade 70-50-05, ductile iron designed for A-16, structural loading. Meets AASHTO M306
b. Grate style: Bar, Flat
c. Frame style: Top Flange, Reversible, Bottom Flange
d. Coating: Asphaltic Coated
e. Color: Black
f. Origin of manufacture: USA
g. Clear opening depth: 24-in minimum, unless otherwise indicated
h. Clear opening length: 24-in minimum, unless otherwise indicated
i. Cover/Grate opening depth: 2-in
j. Cover/Grate opening width: 26-in
k. Cover/Grate opening length: 26in
l. Flange inner length: 26-in
m. Flange inner width: 26-in
n. Flange outer length: 32-in
o. Flange outer width: 32-in
p. Frame height: 6-in
q. Frame outside length: 27.5-in
r. Frame outside width: 27.5-in
s. Grate thickness: 2-in
t. Grate length: 25.75-in
u. Grate width: 27.75-in
v. Grate open area: 321 sq. in.
w. Grate wetted perimeter: 103-in
x. Slot width: 1.5-in
y. Tag Text: “Drains To Waterways Dump No Waste!”

3. Basis-of-Design Product: Subject to compliance with requirements, provide EJ Group Inc., Product No. 45726033C03 – “Classic Series V5626-2 REV 6” V5726 EXHD DI GR SET” by EJ Group Inc. (East Jordan Iron Works), 301 Spring Street, East Jordan, MI 49727 Telephone: 1-800-874-4100.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch ID by 7 to 9-inch riser with 4-inch minimum width flange, and 26-inch- diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent unless otherwise indicated.

## 2.9 DRY WELLS

A. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:

1. Floor: Cast-in-place concrete.

2. Cover: Liftoff-type concrete cover with cast-in lift rings.

3. Wall Thickness: 4 inches minimum with 1-inch diameter or 1-by-3-inch- maximum slotted perforations arranged in rows parallel to axis of ring.

   a. Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
   b. Ring Construction: Designed to be self-aligning.

4. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch washed, crushed stone or gravel.

## 2.10 STORMWATER MANHOLE

A. Standard Precast Concrete Stormwater Manholes:

1. Diameter: 48 inches minimum unless otherwise indicated.

2. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.

3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.

4. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.

5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.

6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.

7. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.

8. Grade Rings: Include two or three reinforced-concrete rings, of 6 to 9-inch total thickness, that match 24-inch diameter frame and grate, and height as required to adjust manhole frame and cover to indicated elevation and slope.

9. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches.

10. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.

11. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

## 2.11 STORMWATER MANHOLES / DRYWELL – FRAMES AND GRATES / COVERS

A. Frames and Grates (Open Grates):

1. Description: Castings of uniform quality, free from blow holes, porosity, hard spots, shrinkage defects, cracks, or other injurious defects. Manufactured true to pattern and free from surface imperfections. Provide machined horizontal bearing surfaces on heavy duty round frames and grates and fabricate round frames and grates in pavement of non-rocking design or with machined bearing surfaces. Grinds finish other units to proper fit.

2. Frame and Grate

    a. Material: Class 35B Cast Iron
    b. Loading Requirements: AASHTO M306 (Meets or Exceeds H20 Loading)
    c. Coating: Shop Dipped Black Asphaltum.

3. Frame:

    a. Frame Depth: 7-inches
    b. Clear open width: 24 inches
    c. Overall frame width: 36 inches diameter

4. Grate – Non-ADA Flat Grate:

    a. 26 inch open diameter
    b. Grate Open Area: 190 square inches
    c. Lettering: “Dump No Waste”

5. Grate – ADA Flat Grate:

    a. 26 inch open diameter
    b. Grate Open Area: 130 square inches
    c. Lettering: “Dump No Waste”

6. Basis of Design: Similar to Frame “Model #1045 (#00104510) and Grate “Type M3 ADA Grate” (#00104036) by East Jordan Iron Works, Inc.

7. 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. Neenah Foundry Co.
    b. East Jordan Iron Works, Inc (EJ Group, Inc.)
    c. Campbell Foundry
    d. General Foundries

B. Frames and Covers (Solid Cover):

1. Description: Castings of uniform quality, free from blow holes, porosity, hard spots, shrinkage defects, cracks, or other injurious defects. Manufactured true to pattern and free from surface imperfections. Provide machined horizontal bearing surfaces on heavy duty round frames and covers and fabricate round frames and covers in pavement of non-rocking design or with machined bearing surfaces. Grinds finish other units to proper fit. Apply shop coat of asphaltum to all units.

2. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

3. Material: Heavy Duty Round Frame and Covers, weight at least 350 lbs, meeting ASTM A 48/A 48M, Class 35 gray iron unless otherwise indicated.

4. 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. Neenah Foundry Co.
   b. East Jordan Iron Works, Inc (EJ Group, Inc.)
   c. Campbell Foundry
   d. General Foundries

## 2.12 IDENTIFICATION

A. Underground Warning Tape

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. Presco, Inc.; Sherman, Texas
   b. EMED Co., Buffalo, New York.
   c. Seton Identification Products, A Tricor Direct Company.

2. Material: 6-inch wide, color-coded, heavy gauge 5-mil tape with aluminum backing.

3. All tapes printed with black ink on APWA (American Public Works Association) approved colors to meet or exceed industry standards.

4. Location: Provide warning tape 18 inches feet below finished grade in buried piping trenches and at foundation wall.

## 2.13 CONCRETE

A. Cast-in-Place Concrete: Refer to Div 03 concrete section for concrete strength, mixtures, fiber reinforcement and other requirements.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

### 3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.

2. Install piping NPS 6 and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.

3. Install piping with 24-inch minimum cover.

4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

5. Install corrugated steel piping according to ASTM A 798/A 798M.

6. Install PE corrugated sewer piping according to ASTM D 2321.

7. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

## 3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
3. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
4. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
5. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
6. Join dissimilar pipe materials with nonpressure-type flexible couplings.

## 3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
2. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.

B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

## 3.5 DRAIN INSTALLATION

A. Install type of drains in locations indicated.

1. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
2. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.

B. Embed drains in 4-inch minimum concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

## 3.6 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.
B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere unless otherwise indicated.

## 3.7 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.
B. Set frames and grates to elevations indicated.

## 3.8 STORMWATER INLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
B. Construct riprap of broken stone, as indicated.
C. Install outlets that spill onto grade, anchored with concrete, where indicated.
D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
E. Construct energy dissipaters at outlets, as indicated.

## 3.9 DRY WELL INSTALLATION

A. Excavate hole to diameter of at least 6 inches greater than outside of dry well. Do not extend excavation into ground-water table.

B. Install precast, concrete-ring dry wells according to the following:

1. Assemble rings to depth indicated.
2. Extend rings to height where top of cover will be approximately 8 inches below finished grade.
3. Backfill bottom of inside of rings with filtering material to level at least 12 inches above bottom.
4. Extend effluent inlet pipe 12 inches into rings and terminate into side of tee fitting.
5. Backfill around outside of rings with filtering material to top level of rings.
6. Install cover over top of rings.

## 3.10 CONCRETE PLACEMENT

A. Place and test cast-in-place concrete according to ACI 318 and Division 03 concrete section**.**

## 3.11 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."

B. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3,000 psi.

2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3,000 psi.

3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.

    a. Use concrete that will attain a minimum 28-day compressive strength of 3,000 psi unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use non-pressure-type flexible couplings where required to join gravity-flow, non-pressure sewer piping unless otherwise indicated.

    a. Unshielded flexible couplings for same or minor difference OD pipes.
    b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

## 3.12 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.

2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.

2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Division 31 Section "Earth Moving."

## 3.13 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.14 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.

2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.

4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.

2. Test completed piping systems according to requirements of authorities having jurisdiction.

3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.

4. Submit separate report for each test.

5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

   a. Exception: Piping with soil tight joints unless required by authorities having jurisdiction.
   b. Option: Test plastic piping according to ASTM F 1417.
   c. Option: Test concrete piping according to ASTM C 924.

C. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

## 3.15 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION 33 41 00