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WAVERLY CENTRAL SCHOOL DISTRICT

WAVERLY, NEW YORK

PROJECT NO. 339070-25002

PHASE 2

ADDITIONS AND ALTERATIONS TO ELM STREET ELEMENTARY SCHOOL

VOLUME 2 OF 2

February 23, 2026

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. Kevin C. Terry is accredited to the EPA and New York State under AHERA Regulations as an Asbestos Project Designer (Asbestos Handling Certificate Number 14-20336).

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. It is a violation of the Education Law of the State of New York for any person to alter or modify this document in any way unless acting under the direction of a professional architect.

BID SET

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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 foodservice 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. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

- F. 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.
- G. Potable Water Outlets: Includes external outlets (hose bibs) and any internal outlets that may be used for drinking or cooking (including food preparation) or potentially used for drinking or cooking. Outlets include:
 - 1. Bubblers/drinking fountains/water coolers/bottle fillers.
 - 2. Classroom sinks.
 - 3. Classroom combination sinks and bubblers.
 - 4. Kitchen sinks.
 - 5. Kitchen kettle filler outlets.
 - 6. Ice machines.
 - 7. Toilet room lavatories.
 - 8. Teachers' lounge sinks.
 - 9. Nurse's office sinks.
 - 10. Hose bibbs.
 - 11. Athletic field outlets.

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. Water distribution systems.
 - 4. Plumbing fixtures.
 - 5. Natural gas piping systems.
 - 6. Electrical control wiring to equipment furnished in this Contract.
 - 7. 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 requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 13 "Access Doors and Frames."
4. 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.
5. Notify Owner's Project Representative and Architect in case of unresolved interferences prior to installation of Plumbing Work.
6. 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. Lab results for lead testing prior to commencing work.
- 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.
 - 2. Comply with applicable Utility Company Regulations.
 - 3. Obtain and pay for necessary inspections, certificates, and permits from applicable agencies. Perform required tests in accordance with regulation of agency having jurisdiction. Submit certificates of approval prior to the date of Substantial Completion as defined in Section 01 77 00 "Closeout Procedures".
- 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. Potable water testing for lead prior to commencing any work: A baseline for lead testing must be set. Coordinate with Owner to schedule potable water lead testing in each building where modifications to the potable water outlets are to take place.
2. Engage a qualified laboratory to test water samples from all potable water outlets scheduled for replacement in accordance with NYS Law 10 CRR-NY 67-4.

B. Take note of any existing potable water outlets scheduled for replacement that exceed the action level (5 micrograms per liter) according to NYS Law 10 CRR-NY 67-4.

C. 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" and 22 14 23 "Storm Drainage 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.

D. 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.
 - a. Provide plastic grommets on pipes running horizontally through metal studs to eliminate rubbing on above grade piping installations. Refer to Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for plastic grommet requirements.
 - 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.
- E. 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 ACCESS DOORS

- A. Comply with requirements for access doors specified in Section 08 31 13 "Access Doors and Frames" for product requirements.
- B. Access Door Sizes for Plumbing Applications:
 - 1. Single Valve:
 - a. 1 NPS and Smaller Valve Size: 8 inches by 8 inches.
 - b. 1-1/2 NPS and 2 NPS Valve Size: 12 inches by 12 inches.
 - c. 3 NPS and 4 NPS Valve Size: 18 inches by 18 inches.

2. Two Valves:
 - a. 2 NPS and Smaller Valve Size: 12 inches by 12 inches.
 - b. 3 NPS and 4 NPS Valve Size: 18 inches by 18 inches.
3. Condensate Drain Connection: 18 inches by 18 inches.
4. Other Devices: 12 inches by 12 inches.

2.6 PAINT AND FINISHES

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

2.7 FOODSERVICE EQUIPMENT AND FIXTURES

- A. Refer to Section 11 40 00 "Foodservice Equipment" for foodservice equipment and fixtures requiring plumbing piping rough-ins and connections.
- B. Provide plumbing piping rough-ins and connections to food service fixtures and equipment.
- C. Provide plumbing piping rough-ins and connections to relocated food service fixtures and equipment.
- D. Verification of Locations and Dimensions
 1. New Equipment: Verify exact locations and roughing-in dimensions for each connection and installation from equipment shop drawings furnished by Contractor Responsible for Kitchen Equipment before beginning installation and provide required adjustments to locations or dimensions.
 2. Relocated Equipment: Verify exact locations and roughing-in dimensions for each connection and installation of relocated equipment and fixtures by inspecting existing installations prior to removal and relocation. Disconnect existing equipment to be relocated or removed.
- E. Provide final plumbing connections to kitchen equipment including interconnecting and final hook-up of plumbing fixtures and piping, valves, traps, fittings, shutoff valves etc. required for complete and operating system.
- F. Install loose plumbing devices, i.e. faucets, pressure regulators relief valves, vacuum breakers, strainers, drains, etc. furnished with kitchen equipment and fixtures at locations indicated on approved equipment shop drawings and equipment product data sheets submitted by Contractor Responsible for Kitchen Equipment. Obtain receipt of delivery for materials supplied by Prime Contractor(s).
- G. Provide indirect waste from kitchen equipment and fixtures at locations indicated on equipment shop drawings and equipment product data sheets submitted by Contractor Responsible for Kitchen Equipment. Obtain receipt of delivery for materials supplied by Prime Contractor(s). Route indirect waste to floor drains or floor sinks with air gap at terminus.

- H. Verify exact locations and roughing-in dimensions for each connection and installation from Roughing Drawings and Assembly Drawings of kitchen equipment accepted by Architect before beginning installation. Obtain Roughing Drawings and Assembly Drawings from Contractor Responsible for Kitchen Equipment Installation.
- I. Install plumbing rough-ins as required for complete and operable installation meeting installation guidelines established by equipment manufacturer.
- J. Install accessible plumbing systems and components in locations and arrangement to allow for regular cleaning of surfaces. Do not support piping from floor where regular cleaning is required.
- K. Maintain 6-inch clear space between floor and plumbing piping, valves, fitting, devices to aid in cleaning floors. Provide supports to bracing piping from walls or equipment.

2.8 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 PROJECT/SITE CONDITIONS

A. Perform the following tests and inspections:

1. Lead Testing Prior to Commencing Construction:

- a. Engage a qualified laboratory to collect and test water samples from all potable water outlets scheduled for replacement in accordance with NYS Law 10 CRR-NY 67-4.
- b. Collect a first-draw sample from a cold-water outlet at each potable water outlet in the building where outlets are scheduled to be replaced as a part of this Contract.
- 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 Owner and Architect/Engineer as a base line of water quality in the building before construction.
 - 1) Notify Owner and Architect in writing of any potable water outlets that exceed the lead action level (5 micrograms per liter).

2. Lead Testing After Construction is Complete:

- a. Engage a qualified laboratory to collect and test water samples in accordance with NYS Law 10 CRR-NY 67-4.
- b. Collect a first-draw sample from all potable water outlets in the building where outlets were replaced or added as a part of this Contract.
- 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 Owner and Architect/Engineer.
 - 1) Notify Owner and Architect in writing of any potable water outlets that exceed the lead action level (5 micrograms per liter).
- d. Potable water outlets replaced under this contract that exceed the lead action level (5 micrograms per liter):
 - 1) Compare to the levels recorded prior to construction. If levels are increased from pre-construction levels, replace faucets and/or supply stops with new materials, and retest portion thereof until sample results are at or below the preconstruction level.
 - 2) Notify Owner and Architect in writing of any potable water outlets that continue to exceed the lead action level (5 micrograms per liter).

- e. Newly installed potable water outlets that exceed the lead action level (5 micrograms per liter):
 - 1) 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).
 - 2) Notify Owner and Architect in writing of any potable water outlets that continue to exceed the lead action level (5 micrograms per liter).
 - 3) Coordinate with the Owner and Architect to implement a Remedial Action Plan to mitigate the lead level at the outlet.

3.2 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.

3.3 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.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Sections, Section 22 05 29 “Hangers and Supports for Plumbing Piping and Equipment”, for detailed additional requirements.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.5 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.

3.6 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.

3.7 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.

3.8 ACCESS DOORS

- A. Install access doors according to the requirements specified in Section 08 31 13 "Access Doors and Frames."
- B. Install access doors where shown on Drawings or where required for access to plumbing system components requiring service (i.e. valves, equipment, slip joints, unions, gauges, etc.) and are located in concealed installations.

3.9 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.

3.10 DIELECTRIC FITTINGS

- A. Install dielectric 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 SLEEVES WITH WATERSTOP

- 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).

- B. Description: Manufactured galvanized steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

2.3 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2. Wade; a subsidiary of McWane Inc.
 - 3. Zurn Industries, LLC.
- B. Description: Manufactured, Dura-coated or Duco-coated galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.4 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."

2.5 GROUT

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

2.6 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-inch annular 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 07 84 13 "Penetration Firestopping."

3.3 INSTALLATION OF SLEEVES WITH WATERSTOP

- A. Install sleeve with waterstop as new walls and slabs 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 sleeves. Select to maintain fire resistance of floor/slab/wall.

3.4 INSTALLATION OF STACK-SLEEVE FITTINGS

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00 "Sheet Metal Flashing and Trim."
 - 2. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 3. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 4. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.5 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.

3.6 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.

3.7 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 or stack-sleeve fittings.
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.
 - 2. Gauges.

1.3 SUBMITTALS, GENERAL

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

1.4 ACTION SUBMITTALS

- A. 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.
 - 3. Dial-type pressure gauges.
 - 4. Snubbers.
 - 5. Valves.

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.

2.4 PRESSURE GAUGES, DIAL TYPE, LEAD FREE - DIRECT MOUNTED, METAL CASE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Weiss Instruments, Inc; Series 4CTSLF or a comparable product by one of the following:
 - 1. Ernst Flow Industries.
 - 2. Tel-Tru Manufacturing Company.
 - 3. Trerice, H. O. Co.
- B. Source Limitations: Provide dial-type, lead-free, direct-mounted, metal-case pressure gauges from single manufacturer.
- C. Standard: ASME B40.100.
- D. Case: Liquid-filled, sealed solid-front, pressure-relief type(s); stainless-steel; 4-1/2-inch nominal diameter.
- E. Pressure-Element Assembly: Lead-free Bourdon tube.
 - 1. Pressure Connection: Lead-free brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 2. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 3. Dial: White coated metal lithographed with black scale markings graduated in psi.
 - 4. Pointer: Dark-colored metal.
 - 5. Window: Safety glass lens.
 - 6. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAUGE ATTACHMENTS, LEAD FREE

- A. Snubbers: ASME B40.100, lead-free brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Lead-free brass or stainless-steel quarter turn ball valve, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

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.
- G. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at most readable position.
- H. Install remote-mounted pressure gauges on panel.
- I. Install valve and snubber in piping for each pressure gauge for fluids.
- J. Install test plugs in piping tees.

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 inlet and outlet of each domestic water heater 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.

3.7 PRESSURE-GAUGE APPLICATION

- A. Pressure gauges at suction and discharge of each domestic water pump are to be the following:
 - 1. Liquid filled, sealed solid front, pressure relief, direct mounted, metal case.

3.8 PRESSURE-GAUGE SCALE-RANGE APPLICATION

- A. Scale Range for Domestic Water Piping:
 - 1. 0 to 100 psi.

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. Butterfly valves.
3. Check valves.
4. Plug 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. PTFE: Polytetrafluoroethylene.
- G. RPTFE: Reinforced polytetrafluoroethylene.
- H. RS: Rising stem.
- I. SWP: Steam working pressure.
- J. 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. Butterfly valves.
 3. Check valves.
 4. Lubricated plug 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, grooved ends, press ends, solder ends, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.
5. 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 piping valves intended to convey or dispense water for human consumption must comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372; or to be certified in compliance with NSF 61/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.

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 B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper solder-joint connections.
6. ASME B16.22 for wrought-copper solder-joint connections.
7. ASME B16.34 for flanged- and threaded-end connections.
8. ASME B16.51 for press joint connections.
9. 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 unacceptable.
- 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 Bypass and Drain Connections: MSS SP-45.
- H. Valve Actuator Type:
 - 1. Hand Lever: For quarter-turn ball valves smaller than NPS 4.
- I. Valves in Insulated Piping:
 - 1. Provide 2-inch extended neck stems.
 - 2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Provide memory stops that are fully adjustable after insulation is applied.

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: PTFE or TFE 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 DUCTILE IRON, SINGLE-FLANGE (LUG-TYPE) BUTTERFLY VALVES

A. Iron, Single-Flange (Lug-Type) Butterfly Valves with Aluminum-Bronze Disc:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; LD-2000. or a comparable product by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond Valve.
 - c. Jenkins Valves; a Crane Co. brand.
 - d. Legend Valve & Fitting, Inc.
 - e. Milwaukee Valve Company.
 - f. Stockham; a Crane Co. brand.
 - g. WATTS.
2. Standard: MSS SP-67, Type I.
3. CWP Rating: 200 psig.
4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
5. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.

6. Seat: EPDM.
7. Stem: One- or two-piece stainless steel.
8. Disc: Aluminum bronze.

2.5 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Ductile Iron, Grooved-End Butterfly Valves, 300 CWP:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model GD-4765N or a comparable product by one of the following:
 - a. Hammond Valve.
 - b. Kennedy Valve Company; a division of McWane, Inc.
 - c. Red-White Valve Corp.
 - d. Shurjoint; a part of Aalberts Integrated piping Systems.
 - e. Victaulic Company.
 - f. WATTS.
2. Standard: MSS SP-67, Type I.
3. CWP Rating, NPS 8 and Smaller: 300 psig.
4. CWP Rating, NPS 10 and Larger: 200 psig.
5. Body Material: Coated, ductile iron.
6. Stem: Two-piece stainless steel.
7. Disc: Coated, ductile iron.
8. Seal: EPDM.

2.6 SILICON BRONZE SWING CHECK VALVES

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

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; T/S/PC-413-Y-LF or comparable product by one of the following:
 - a. Hammond Valve.
 - b. Milwaukee Valve Company.
 - c. WATTS.

2. Description:

- a. Standard: MSS SP-139.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Design: Horizontal or vertical (flow in upward direction) flow.
- d. Body Material: Silicon bronze (ASTM listed), corrosion resistant.
- e. Ends: Threaded, soldered, or press. See valve schedule articles.
- f. Disc: PTFE.

2.7 LUBRICATED PLUG VALVES

A. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Homestead Valve; a division of Olson Technologies, Inc.
 - b. Milliken Valve Company.
 - c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
- 2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: Regular or short.
 - e. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Homestead Valve; a division of Olson Technologies, Inc.
 - b. Milliken Valve Company.
 - c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
- 2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: Regular or short
 - e. Plug: Cast iron or bronze with sealant groove.

C. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Homestead Valve; a division of Olson Technologies, Inc.
 - b. Milliken Valve Company.
 - c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. CWP Rating: 400 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: Regular or short.
 - e. Plug: Cast iron or bronze with sealant groove.

D. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Homestead Valve; a division of Olson Technologies, Inc.
 - b. Milliken Valve Company.
 - c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. CWP Rating: 400 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
 - d. Pattern: Regular or short.
 - e. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.

- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.
- 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. Swing Check Valves: In horizontal position with hinge pin level.
- 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 or butterfly valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing 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 Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 3. For Grooved-End Copper Tubing: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 2. Bronze Ball Valves: Two-piece with full port and stainless-steel trim. Provide with threaded, solder or press connection-joint ends.
 3. Bronze Ball Valves: Three-piece with full port and stainless-steel trim.
 4. Silicon Bronze Swing Check Valves: Class 125, nonmetallic disc.
- B. Pipe NPS 2-1/2 and Larger:
1. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.
 2. Iron, Grooved-End Butterfly Valves: 300 CWP.
 3. Iron Swing Check Valves: Class 125, metal seats.
 4. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
 5. Iron, Grooved-End Swing Check Valves: 300 CWP.
 6. Iron, Center-Guided Check Valves: Class 125, globe, resilient seat.
 7. Iron Gate Valves: Class 250, OS&Y.

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. Metal framing systems.
 - 4. Thermal hanger-shield inserts.
 - 5. Fastener systems.
 - 6. Pipe-positioning systems.
 - 7. 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. Riser clamps.
 7. Beam Clamps.
- C. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Trapeze pipe hangers.
 2. Equipment supports.

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: Pre-galvanized, 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. 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 PIPE-POSITIONING SYSTEMS

- A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.7 PLASTIC GROMMETS

- A. Snap-in type plastic grommets for stud webs to protect plumbing piping. Prevent metal-to-metal contact between piping and studs.

2.8 EQUIPMENT SUPPORTS

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

2.9 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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. 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.
- F. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

- I. 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.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. 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.
- L. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. 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.
- N. 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.
 - 5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/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.

3.5 PLASTIC GROMMETS

- A. Provide grommets for bare pipes penetrating vertically or horizontally through metal stud knockouts.

3.6 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.

3.7 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.
- A. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in and Section 09 96 00 "High-Performance Coatings" for interior installations.

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

3.8 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 support, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal hanger-shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Piping in general service applications:
 - a. Piping Installed in Metal Stud Cavities:
 - 1) NPS 1/2 to 3/4: After tubing and continuous insulation passes through the hole in stud or bracket, position the insert around tubing and push insert through the hole until the tabs click and lock into place.
 - b. 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.
 - c. 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.

- d. 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.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. 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.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- P. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

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. 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.
- C. Samples: For color, letter style, and graphic representation required for each identification material and device.
- D. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- E. Valve-numbering scheme.
- F. Valve Schedules: For each piping system. 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 WARNING SIGNS AND 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances 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.
- G. Fasteners: Stainless steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA 70E

- J. Label Content: Include caution and warning information plus emergency notification instructions.
1. Grease interceptors: A minimum nominal width of 14 inches and a minimum nominal height of 10 inches and to read as follows:



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. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. 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.
- F. 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 STENCILS

- 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. Craftmark Pipe Markers.
 - 2. Kolbi Pipe Marker Co.
 - 3. Marking Services Inc.
 - 4. Pipemarker.com; Brimar Industries, Inc.
- B. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 - 1. Stencil Material: Aluminum, brass, or fiberboard.
 - 2. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, acrylic enamel in colors in accordance with ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 4. Letter and Background Color: As indicated for specific application under Part 3.

2.4 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.

2.5 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. Stop and drain valves serving an exterior wall hydrant: Text to read "Wall Hydrant Shutoff Valve and Drain Plug".
 - 2. Bypass valves: Text to read "Bypass Valve-Normally Closed".

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.

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. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- D. 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.
- E. 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.
- F. 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.

G. 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.

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. Roof drains and rainwater leaders.
 - 5. Supplies and drains for handicap-accessible lavatories and sinks.

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. Cellular glass.
 - 2. Flexible elastomeric insulation.
 - 3. Mineral-fiber, preformed pipe insulation.
 - 4. Spray polyurethane foam.
 - 5. Mineral-fiber, hydraulic-setting insulating and finishing cement.
 - 6. Vapor-barrier mastic.
 - 7. Protective shielding piping enclosures.

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.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing 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 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.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

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."

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground 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."

2.2 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.; Aero seal.
 - 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.

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.

2.3 MASTICS

A. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
 - b. Eagle Bridges - Marathon Industries; 501.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
 - d. Mon-Eco Industries, Inc.; 55-10.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

2.4 SEALANTS

A. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing, self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.6 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.

2.7 SECUREMENTS

- A. Bands:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
 2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
- B. Wire: 0.062-inch soft-annealed, stainless steel.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. C & F Wire.

2.8 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Piping Enclosures:

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. Truebro; a brand of IPS Corporation.
 - b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

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.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of 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. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive along both edges of strip.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere and seal patches similar to butt joints.

- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.
- Q. Miscellaneous Voids: Install insulation where indicated and in miscellaneous openings and penetrations in the exterior building envelope, including pipe sleeves, exterior wall hydrants, roof drains, downspout nozzles, pipe chases located on exterior walls, voids and cavity spaces created by Plumbing Work where required to provide continuity and integrity to the building exterior envelope insulation system, sealing gaps and preventing air infiltration, using the following materials:
1. Loose-Fill Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft.
 2. 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 Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. 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. Install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulation Installation on Roof Drain Bodies:

1. Insulate roof drain bodies using preformed fitting insulation. 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.
2. Adhere fitted PVC cover to insulated Roof Drain Body with PVC Jacket Adhesive. Tape PVC covers to adjoining insulation facing using PVC tape. Seal voids to maintain vapor barrier on drain body assembly.

D. 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.

E. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. Secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - 2. Seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - 3. 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.

3.9 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.

3.10 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, horizontal runs in metal stud walls 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. Pipes size 1 1/4" or smaller: 1-inch thickness.
 - b. Pipes size 1 1/2" or larger: 1-1/2-inch thickness.

- D. Domestic Hot and Recirculation Water located within Masonry Block Wall cores, horizontal runs in metal stud walls or buried conduits:
 - 1. Flexible Elastomeric Insulation:
 - a. Pipes size 1 1/4" or smaller: 1/2-inch thickness.
 - b. Pipes size 1 1/2" or larger: 1-inch thickness.
 - E. Freezer Condensate Piping:
 - 1. Flexible Elastomeric Insulation: 1/2-inch thick.
 - F. Stormwater and Overflow:
 - 1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-inch thick.
 - G. Roof Drain and Overflow Drain Bodies:
 - 1. Mineral-Fiber, Preformed Pipe Insulation without factory applied jacket, Type I: 2-inch thick.
 - H. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. Protective Shielding Pipe Enclosure.
- 3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE
- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - B. Piping, Exposed:
 - 1. PVC: 30 mils thick.

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. Copper tube and fittings.
 - 2. Piping joining materials.
 - 3. Transition fittings.
 - 4. 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. System purging and disinfecting activities report.
- B. Lab results for lead testing upon completion of work.

1.5 CLOSEOUT SUBMITTALS

- A. Field quality-control reports.
- B. Lab results for biological testing showing samples negative for coliform bacteria.

1.6 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.

1.7 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. Refer to the “Project/Site Conditions” article for lead testing requirements prior to commencing any work in Section 22 05 00 “Common Work Results for Plumbing.”
- C. 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. 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.
- F. Wrought Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.

G. Grooved, Mechanical-Joint, Copper Tube Appurtenances - Domestic Water:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASC Engineered Solutions.
 - b. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 - c. Shurjoint; a part of Aalberts Integrated piping Systems.
 - d. Victaulic Company.
2. Source Limitations: Obtain grooved, mechanical-joint copper tube appurtenances from single manufacturer.
3. Grooved-End, Copper Fittings: ASTM B75/B75M copper tube or ASTM B584 bronze castings.
4. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting, EPDM-rubber gasket, UL classified per NSF 61 and NSF 372, and rated for minimum 180 deg F, for use with ferrous housing and steel bolts and nuts; 300 psig minimum CWP pressure rating.

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. Refer to the "PROJECT/SITE CONDITIONS" article for lead testing requirements prior to commencing any work in Section 22 05 00 "Common Work Results for Plumbing."
- B. 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.
- 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. Under-building-slab, domestic water piping, NPS 2 and smaller is to be the following:
 - 1. Drawn-temper or annealed-temper copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

- D. Aboveground domestic water piping, NPS 4 or smaller is to be one of the following:
1. Drawn-temper copper tube, ASTM B88, Type L; cast-or wrought- 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. Drawn-temper copper tube, ASTM B88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.

3.3 EARTHWORK

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

3.4 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 valves in accordance with Section 22 05 23 "General Duty Valves for Plumbing Piping."
- D. Install domestic water piping level without pitch and plumb.
- E. Rough-in domestic water piping for water-meter installation in accordance with utility company's requirements.
- F. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- G. 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.
- H. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- I. Install piping to permit valve servicing.
- J. 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.
- K. Install piping free of sags and bends.
- L. Install fittings for changes in direction and branch connections.

- M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- N. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gauges in Section 22 05 19 "Meters and Gauges for Plumbing Piping."
- O. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23.21 "Inline, Domestic Water Pumps."
- P. 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."
- Q. 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."
- R. 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 PROTECTION

- A. Thermal expansion and contraction: Wrap copper and copper alloy tube passing through a wall, floor, ceiling or partition with tape or pipe insulation. Install tube through an appropriately sized sleeve to allow for thermal movement.
- B. Protect against abrasion where copper and copper alloy tube contacts building materials. Wrap tube with tape, pipe insulation, metal stud insulating pipe clamps or suitable method of isolation.
- C. Backfill trench and excavations with clean fill which contains no ashes, cinders, refuse, stones, boulders, or other materials which can damage piping or promote corrosive action.
- D. Where excessive moisture is anticipated, wrap piping and support hanger with tape to prevent dissimilar metals galvanic corrosion of supporting member.

3.6 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. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- E. 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."
- F. 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.
- G. Joint Construction for Grooved-End Copper Tubing: Make joints in accordance with AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
- H. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.7 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 and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.8 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings, nipples or unions.

3.9 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.

3.10 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. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 - 2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 - 3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.11 IDENTIFICATION

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

3.12 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. Clean non-potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.13 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.
 - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 - 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 - 7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
 - 8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.14 FIELD QUALITY CONTROL

A. Perform the following tests:

1. Comply with "Field Quality Control" article in Part 3 of Section 22 05 00 "Common Work Results for Plumbing" for lead testing requirements prior to commencing any work.
2. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been tested and inspected by the Owner's Representative.
 - b. During installation, notify Owner's Representative at least two days before inspection must be made. Perform tests specified below in presence of Owner's Representative:
 - 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 Owner's Representative 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 Owner's Representative.
3. 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 psi, 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 psi 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.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. 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. Balancing valves.
 - 2. Strainers for domestic water piping.
 - 3. Hose bibbs.
 - 4. Wall hydrants.
 - 5. Drain valves.
 - 6. Water-hammer arresters.

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.
 - 1. Nonfreeze wall hydrants.
 - 2. Moderate-climate wall hydrants.
 - 3. Stop-and-waste drain valves.
 - 4. Water hammer arresters.
- 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. Hose bibbs.
 - 2. Hose-end drain valves.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
- B. Test and inspection reports.
- C. Field quality-control reports.

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 BALANCING VALVES

- A. Memory-Stop Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO INC.; Model S-585-66-LF-NS-M or T-585-66-LF-NS-M or a comparable product by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. Watts; a Watts Water Technologies Company.
2. Description:
 - a. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
 - b. Pressure Rating: 400-psig minimum CWP.
 - c. Size: NPS 2 or smaller.
 - d. Body: Lead free copper alloy.
 - e. Port: Full port.
 - f. Ball: Chrome-plated brass.
 - g. Seats and Seals: Replaceable.
 - h. End Connections: Solder joint or threaded.
 - i. Handle: Vinyl-covered steel with memory-setting device.

2.4 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Inc; Model T-222-A or F-721-A or comparable product by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Div.
 - e. Hammond Valve.
 - f. Milwaukee Valve Company.
 - g. Watts; a Watts Water Technologies Company.
 - h. Zurn Industries, LLC.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
7. Drain: Pipe plug.

2.5 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include wall flange with each chrome- or nickel-plated hose bibb.

2.6 WALL HYDRANTS

A. Non-freeze Wall Hydrants (EXT WH):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; Model No. 5509-QT-NB or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Prier Products, Inc.
 - d. WATTS.
 - e. Woodford Manufacturing Company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Recessed stainless steel, flush mounted with cover.
9. Cover Finish: Polished nickel bronze.
10. Operating Keys(s): One with each wall hydrant.

B. Moderate-Climate Wall Hydrants (INT WH):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; Model No. 5509-QT-SAP-CP or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Prier Products, Inc.
 - d. WATTS.
 - e. Woodford Manufacturing Company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.

5. Inlet: NPS 3/4 or NPS 1.
6. Outlet:
 - a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
 - b. Garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Chrome plated.
9. Operating Keys(s): Two with each wall hydrant.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Inc; Model T-585-70-HC or comparable product by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Div.
 - e. Hammond Valve.
 - f. Milwaukee Valve Company.
 - g. Red-White Valve Corp.
2. Standard: MSS SP-110 for standard-port, two-piece ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 3/4.
5. Body: Copper alloy.
6. Ball: Chrome-plated brass.
7. Seats and Seals: Replaceable.
8. Handle: Vinyl-covered steel.
9. Inlet: Threaded or solder joint.
10. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Stop-and-Waste Drain Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO Inc.; S-FP-600-AD-LF or comparable product by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Standard: MSS SP-110 for ball valves.
3. Pressure Rating: 200-psig minimum CWP or Class 125.
4. Size: NPS 3/4.
5. Body: Lead-free copper alloy or ASTM B 62 bronze.
6. Drain: NPS 1/8 side outlet with cap.

2.8 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.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.
- B. Y-Pattern Strainers: For water, install on supply side of pump.
- C. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

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 ADJUSTING

- A. Set field-adjustable flow set points of balancing valves.

3.4 FIELD QUALITY CONTROL

- A. 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.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 22 11 19

SECTION 22 11 23.21 - INLINE, DOMESTIC-WATER 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. In-line circulating pumps.

1.3 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 1. Circulation Pump CP-1.
 - 2. Thermostats.
 - 3. Timers.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.
- B. Field quality-control reports.

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 instructions for handling.

PART 2 - PRODUCTS

2.1 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. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.2 IN-LINE CIRCULATING PUMPS

- 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. Armstrong Pumps Inc.
 - 2. Bell & Gossett Domestic Pump; ITT Corporation.
 - 3. Grundfos Pumps Corp.
 - 4. TACO Incorporated.
 - 5. WILO USA LLC - WILO Canada Inc.
- B. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, overhung-impeller centrifugal pumps.
- C. Capacities and Characteristics: Refer to Schedules on Drawings.
- D. Pump Construction:
 - 1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
 - 2. Minimum Working Pressure: 125 psig.
 - 3. Maximum Continuous Operating Temperature: 220 deg F.
 - 4. Casing: Bronze or stainless steel, with threaded or companion-flange connections.
 - 5. Impeller: Plastic or stainless steel.
 - 6. Motor: Single speed, unless otherwise indicated.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 05 13 "Common Motor Requirements for Plumbing 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.

2.4 CONTROLS

- A. Timers: Electric, for control of hot-water circulation pump.
 - 1. Type: Programmable, seven-day clock with manual override on-off switch.
 - 2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
 - 3. Operation of Pump: On or off.
 - 4. Transformer: Provide if required.
 - 5. Power Requirement: 120-V ac.
 - 6. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump 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 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.
- C. Install thermostats in hot-water return piping.
- D. Install timers on wall in Boiler Room.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping" and comply with requirements for strainers specified in Section 22 11 19 "Domestic Water Piping Specialties."
- E. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gageappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between temperature controllers and devices.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set timers for automatic starting and stopping operation of pumps.

5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
6. Start motor.
7. Open discharge valve slowly.
8. Adjust temperature settings on thermostats.
9. Adjust timer settings.

3.8 ADJUSTING

- A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 22 11 23.21

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.

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. Copper pipe and fittings.
 - 3. Transition couplings.

1.4 CLOSEOUT SUBMITTALS

- A. Field quality-control reports.

1.5 FIELD CONDITIONS

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

1.6 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.

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

2.6 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".

2.7 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 at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install vent piping to allow application of insulation within 10 feet of a roof penetration.
- I. 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.
- J. 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.
- K. 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.
- L. 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."
- M. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

- N. Install engineered soil and waste drainage and vent piping systems as follows:
 - 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
- O. 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. 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."
- P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- Q. 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."
- R. 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."
- S. 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."
- T. 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. 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 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 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 and coupling.
- D. Support vertical runs of cast-iron and copper soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

- C. Connect 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. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.7 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."

3.8 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.

3.9 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.

3.10 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. Aboveground, soil waste and vent pipe exposed to view in Kitchen areas shall be any of the following:
 - 1. Chrome plated, brass tubing.
 - 2. Stainless-steel pipe and fittings, sealing rings, and gasketed joints.
- E. Underground, soil, waste, and vent piping NPS 12 and smaller are to be the following:
 - 1. Service cast-iron soil piping; gaskets; and gasketed joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

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. Roof flashing assemblies.
 - 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. Drain-outlet backwater valves.
 - 2. Floor cleanouts, general building areas.
 - 3. Wall cleanouts.
 - 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
 - 3. Air-gap fittings.

1.4 CLOSEOUT SUBMITTALS

- A. Field quality-control reports.
- B. 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 BACKWATER VALVES

A. Drain-Outlet Backwater Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 7080 or a comparable product by one of the following:
 - a. Josam Company.
 - b. WATTS; A Watts Water Technologies Company.
 - c. Zurn Industries, LLC.
2. Size: NPS 2.
3. Body: Cast iron or bronze made for vertical installation.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.3 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.

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

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg. Co.; Division of Smith Industries, Inc.; No. 4021-U or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.

- c. WATTS; A Watts Water Technologies Company; Model CO-200-R-6-CF.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 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: Round
 - 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; Model CO-380-RD.
 - 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.

2.4 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. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. 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 deep-seal traps on floor drains and other waste outlets, if indicated.
- E. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- F. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- G. Install vent caps on each vent pipe passing through roof.
- H. 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 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 19.13 - SANITARY DRAINS

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. Floor drains.
 - 2. Floor sinks.
 - 3. Trench drains.
 - 4. Channel drainage systems.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Floor drain "A".
 - 2. Floor sink "A".
 - 3. Floor sink "B".

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

2.2 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: Round.
9. Dimensions of Top or Strainer: 7-inch diameter.
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.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks (FS “A”):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 3161-C-11 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 A112.6.7.
3. Pattern: Floor drain.
4. Body Material: Cast iron 10" deep.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom connection.
8. Coating on Interior Surfaces: Acid-resistant enamel.
9. Sediment Bucket: ABS sediment bucket
10. Internal Strainer: Not required.
11. Top Grate Material: Cast iron.
12. Top of Body and Grate Finish: Nickel bronze less grate.
13. Top Shape: Square.
14. Dimensions of Top Grate: 12 ½" square.
15. Top Loading Classification: No traffic.
16. Funnel: Not required.

B. Cast-Iron Floor Sinks (FS "B"):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; No. 3140-C-12 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 A112.6.7.
3. Pattern: Floor drain.
4. Body Material: Cast iron 6" deep.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom connection.

8. Coating on Interior Surfaces: Acid-resistant enamel.
9. Sediment Bucket: Not required.
10. Internal Strainer: Aluminum dome bottom strainer.
11. Top Grate Material: Cast iron.
12. Top of Body and Grate Finish: Nickel bronze ½ grate.
13. Top Shape: Square.
14. Dimensions of Top Grate: 12 ½" square.
15. Top Loading Classification: No traffic.
16. Funnel: Not required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. 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 floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 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. Comply with requirements in Section 22 13 19 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.
- C. Comply with requirements in Section 22 13 23 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- D. Install piping adjacent to equipment to allow service and maintenance.

3.3 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 19.13

SECTION 22 13 23 - SANITARY WASTE INTERCEPTORS

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. Grease interceptors.

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. PP: Polypropylene.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of interceptor. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

1.5 CLOSEOUT SUBMITTALS

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

1.6 FIELD CONDITIONS

- A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
 - 1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of sewer services without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

A. Cast-Iron or Steel Grease Interceptors GI-B-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; Model 8460 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: PDI G101, for intercepting and retaining FOG from food-preparation wastewater.
3. PDI Seal: Required.
4. Body Material: Cast iron or steel.
5. Interior Lining: Corrosion-resistant enamel.
6. Exterior Coating: Corrosion-resistant enamel.
7. Capacities and Characteristics: As scheduled on the drawings
 - a. Mounting: Recessed, flush with floor.
 - b. Flow-Control Fitting: Required.
 - c. Operation: Manual cleaning.

2.2 LABELING AND IDENTIFYING

- #### A. Grease Interceptor Warning Sign: Refer to Section 22 05 53 "Identification for Plumbing Piping and Equipment" for warning signs and basic installation requirements.

PART 3 - EXECUTION

3.1 EARTHWORK

- #### A. Excavating, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.2 INSTALLATION

A. Equipment Mounting:

1. Install grease interceptors on cast-in-place concrete equipment base(s).
2. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."

B. Set interceptors level and plumb.

C. Set interceptors level and plumb.

D. Set tops of metal interceptor covers flush with finished surface in pavements.

E. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.
2. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

3.3 PIPING CONNECTIONS

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

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Grease interceptors.

3.5 PROTECTION

A. Protect sanitary waste interceptors from damage during construction period.

B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 22 13 23

SECTION 22 14 14 - STORM 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, tube, and 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, standard hubless-piping couplings.
 - 2. Transition couplings.
 - 3. Service saddles.

1.4 CLOSEOUT SUBMITALS

- A. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation are capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Storm Drainage Piping: 10 ft. head of water.

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, Standard 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, rubber 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. Huky SD 4000.
 - 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, rubber sleeve with integral, center pipe stop.

2.5 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".

2.6 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 EARTH MOVING

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

3.2 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 from 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 at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
 - 1. Do not change direction of flow more than 90 degrees.
 - 2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of drainage piping in direction of flow is prohibited.
- J. Lay buried building 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.
- K. Install piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Storm Drainage Piping: 1 percent downward in direction of flow.
- L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

M. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
 - a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
 - b. Comply with requirements for cleanouts specified in Section 22 14 23 "Storm Drainage Piping Specialties."
2. Install drains in storm drainage gravity-flow piping.
 - a. Comply with requirements for drains specified in Section 22 14 23 "Storm Drainage Piping Specialties."

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

O. 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."

P. 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."

Q. 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."

3.3 JOINT CONSTRUCTION

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

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

1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: Unshielded, nonpressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

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

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install 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 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
5. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

C. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3: 60 inches with 1/2-inch rod.
2. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
3. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

E. Install supports for vertical cast-iron soil piping every 15 feet.

F. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

- C. Connect storm drainage piping to roof drains and storm drainage specialties.
 - 1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
 - 2. Comply with requirements for cleanout and drains specified in Section 22 14 23 "Storm Drainage Piping Specialties."
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

- A. Identify exposed storm drainage piping.
- B. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - 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 storm drainage piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.

3. Test Procedure:
 - a. Test storm drainage piping on completion of roughing-in.
 - b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 5. Prepare reports for tests and required corrective action.
- C. Piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.9 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, storm drainage piping NPS 4 and larger shall be any of the following:
 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- C. Underground storm drainage piping shall be the following:
 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 22 14 13

SECTION 22 14 23 - STORM DRAINAGE 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. Roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.
 - 4. Flashing materials.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Cast-iron, large-sump, general-purpose roof drains.
 - 2. Drain-outlet backwater valves.
 - 3. Floor cleanouts, general building areas.
 - 4. Wall cleanouts.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, Large-Sump, General-Purpose Roof Drains (RD "A"):
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg. Co.; Division of Smith Industries, Inc.; No. 1015Y-R-C-U-G or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. WATTS; A Watts Water Technologies Company; No. RD-300-AE-B-D-K80-L.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 16-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Outlet: Bottom.
7. Extension Collars: Adjustable required.
8. Underdeck Clamp: Required.
9. Sump Receiver Plate: Required.
10. Dome Material: Galvanized Cast Iron.
11. Vandal-Proof Dome: Required.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Drain-Outlet Backwater Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg. Co.; Division of Smith Industries, Inc.; No. 7080 or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. WATTS; A Watts Water Technologies Company; Model BV-300.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Size: Same as floor drain outlet or storm drain.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain or in vertical storm leader for condensate connection.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.3 CLEANOUTS

A. Exposed Metal Cleanouts (CO):

1. Vertical 6 NPS and Smaller:
 - a. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
 - b. Size: Same as connected drainage piping
 - c. 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.
 - d. Closure: Countersunk or raised-head, brass plug.
 - e. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
2. 8-inch Pipe Size and Larger: Cast bronze tapered plug with tapped test tee cast iron fitting.
3. Horizontal: All Pipe Sizes: Cast iron Tee “Y” fitting with tapped spigot ferrule and cast bronze taper thread plug.

B. Floor Cleanouts (CODP):

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg. Co.; Division of Smith Industries, Inc.; No. 4021-U or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. WATTS; A Watts Water Technologies Company; Model CO-200-R-6-CF.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule Material: Cast iron.
6. Outlet Connection: Spigot.
7. Closure: Brass plug with straight threads and gasket 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: Round.
11. Top-Loading Classification: Medium Duty.
12. Carpet Clamping Collar: Required in carpeted areas.

13. Riser: ASTM A 74, Extra-Heavy or 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.; Division of Smith Industries, Inc.; No. 4531-U or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. WATTS; A Watts Water Technologies Company; Model CO-380-RD.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
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.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of storm drainage piping systems to verify actual locations of specialties installations.
- 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 roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Position roof drains for easy access and maintenance.

- B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate cleanouts at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install drain-outlet backwater valves in condensate connections to vertical conductors.
- F. Install test tees in vertical conductors and near floor.
- G. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- H. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 14 13 "Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.4 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 14 23

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.

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, crawlspace, and tunnels.

1.4 ACTION SUBMITTALS

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

1.5 CLOSEOUT 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: 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 access panels and doors for valves installed and concealed behind finished surfaces. Comply with requirements in Section 08 31 13 "Access Doors and Frames."

B. 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. 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.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5 MANUAL GAS SHUTOFF VALVES

- A. 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.
- B. 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.
- C. 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.

D. 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.

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. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- N. 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.
- O. 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. 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.
 - 2. 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.

- P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- Q. Connect branch piping from top or side of horizontal piping.
- R. 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.
- S. Do not use natural-gas piping as grounding electrode.
- 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 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.

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. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.
- C. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

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.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

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. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.

3.13 INDOOR PIPING SCHEDULE

- A. Aboveground, branch piping NPS 2 and smaller shall be the following:
 - 1. ASTM A53-steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping NPS 2 and smaller shall be one of the following:
 - 1. ASTM A53 steel pipe with malleable-iron fittings and threaded joints.
 - 2. ASTM A53 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 13.13 - COMMERCIAL WATER CLOSETS

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. Water closets.
 - 2. Supports
 - 3. Flushometer valves.
 - 4. Toilet seats.

1.3 DEFINITIONS

- A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.
- B. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

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 product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 1. Water Closet "A" flushometer valves.
- 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. Water Closet "A" bowl.
 - 2. Supports
 - 3. Toilet seats.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

1.8 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.
- B. 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Standards:
 - 1. Comply with ASME A112.19.2/CSA B45.1 for water closets.
 - 2. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets and tanks.
 - 3. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.
 - 4. Comply with IAMPO/ANSI Z124.5 for water-closet (toilet) seats.
 - 5. Comply with ASME A112.6.1M for water-closet supports.
 - 6. Comply with ICC A117.1 for ADA-compliant water closets.
 - 7. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous china water closets to sanitary drainage systems.
 - 8. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous china water closets to sanitary drainage systems.
 - 9. Comply with ASME A112.18.6 for braided or corrugated stainless-steel flexible hose.
- B. Source Limitations: Obtain water closet fixtures, flushometers and accessories from single source from single manufacturer.

2.2 GENERAL CHARACTERISTICS

- A. Vitreous China: Unmarked, true and level, clear, smooth and bright. Warranted not to craze, color or scale.
- B. Trap ways no less than 2-1/8 inches in diameter and fully glazed.
- C. Water surface area no less than 10 inches x 12 inches (254 by 305 mm).
- D. 100 percent factory tested for hydraulic performance, and trap seal depth, meeting or exceeding ANSI/ASME Standard A112.19.6, CSA B45 and a minimum ball pass diameter of 2 inches.

2.3 WALL-MOUNTED WATER CLOSETS

- A. Water Closets (WC "A"): Wall mounted, top spud.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard; AFWall Millennium FloWise Elongated No. 3351.101 or comparable product by one of the following:
 - a. Kohler Co.
 - b. Sloan Valve Company.
 - c. Zurn Industries, LLC.
 - 2. Bowl:
 - a. Material: Vitreous china.
 - b. Type: Siphon jet.
 - c. Style: Flushometer valve.
 - d. Height: Refer to Plumbing Fixture Schedule on Drawings.
 - e. Rim Contour: Elongated.
 - f. Water Consumption: 1.1 gal. – 1.6 gal. per flush.
 - g. Effective Flush Volume: 1.28 gal. per flush.
 - h. Spud Size and Location: NPS 1-1/2; top.
 - i. Outlet: Back.
 - j. Color: White.
 - 3. Support: Comply with requirements in "Support" Article.
 - 4. Flushometer Valve: Battery-Powered, Dual Flush, Flushometer Valves. Comply with requirements in "Flushometer Valve" Article.
 - 5. Toilet Seat: Standard Toilet Seat. Comply with requirements in "Toilet Seat" Article.

2.4 FLUSHOMETER VALVES

A. Battery-Powered, Dual Flush Flushometer Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan Valve Company; Sloan ECOS Model No. ECOS 8111-1.6/1.1-YO-YB or comparable product by the following:
 - a. Zurn Industries, LLC; Commercial Brass and Fixtures.
2. Minimum Pressure Rating: 125 psig.
3. Features: Include angle stop bumper, sweat solder adapter, cast set screw escutcheon, casing tube, integral check stop and backflow-prevention device.
4. Material: Brass body with corrosion and chloramine resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Actuator: Solenoid complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Trip Mechanism: Battery-powered electronic sensor complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
8. Consumption: 1.6 gal./ 1.1 gal. (4.2 liter) per flush.
9. Effective Flush Volume: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

2.5 TOILET SEATS

A. Standards Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Bemis Manufacturing Company.
 - c. Church Seats; Bemis Manufacturing Company.
 - d. Kohler Co.
 - e. ProFlo; a Ferguson Enterprises, Inc. brand.
 - f. Zurn Industries, LLC.
2. Material: Anti-microbial treated fire-retardant plastic.
3. Type: Commercial (Heavy duty).

4. Shape: Elongated rim, open front.
5. Hinge: Self-sustaining, check.
6. Hinge Material: Stainless steel.
7. Seat Cover: Not required.
8. Color: White.

2.6 SUPPORTS

A. Water Closet Carrier:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg.; Series 100 and Series 200 M51 or comparable product by one of the following:
 - a. Josam Company.
 - b. Zurn Industries, LLC.
2. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.
 - a. Provide horizontal carrier fittings with NPS 2 auxiliary no-hub inlet where appropriate for other plumbing fixture vertical pipe connections.
 - 1) Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg.; Series 209 and Series 219 M51 or comparable product.

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 water-closet installation.
- B. Examine walls and floors for suitable conditions where water closets 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. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
5. Measure support height installation from finished floor, not structural floor.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install flushometer valves for accessible water closets such that the operating handle faces the approach or transfer side of the water closet stall. Install sensor operated flushometer valves in the same manner so that, in the event that the sensor operated flushometer valve is replaced by a manually operated valve, the handle will comply with the above requirement.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
2. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
3. Install escutcheon so set screw is facing floor.

F. Joint Sealing:

1. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."
2. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
3. Match sealant color to water-closet color.

3.3 PIPING CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- 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."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.

END OF SECTION 22 42 13.13

SECTION 22 42 16.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.
3. Supplies.
4. Drains.
5. Traps.
6. Supports.

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 lavatories. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Lavatory "A" faucets.

- 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. Lavatory "A" bowls.
2. Supply fittings.
3. Offset tailpiece drains.
4. Standard traps.
5. Supports

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:** For lavatories and faucets to include in operation and maintenance manuals.

1.4 MAINTENANCE 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. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

1.5 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.
- B. 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.

1.6 FIELD CONDITIONS

- A. Comply with “Project/Site Conditions” article in Part 1 of Section 22 05 00 “Common Work Results for Plumbing” for lead testing requirements prior to commencing any work.
- B. Coordinate potable water lead testing with Owner prior to starting any construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Lavatory faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), 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. Source Limitations: Obtain lavatory fixtures, faucets and accessories from single source from single manufacturer.

2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- A. Lavatory (LAV “A”): Vitreous china, wall mounted, accessible with back.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard America; Lucerne No. 0356.015 or comparable product by one of the following:
 - a. Kohler Co.
 - b. Sloan Valve Company.
 - c. Zurn Industries, LLC.

2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: For wall hanging.
 - c. Nominal Size: Rectangular, 20 by 18 inches.
 - d. Faucet-Hole Punching: Three holes, 4-inch centers.
 - e. Faucet-Hole Location: Top.
 - f. Color: White.
 - g. Mounting Material: Chair carrier.
3. Faucet: Manual-type, two-handle metering, centerset commercial, solid-brass valve. Comply with requirements in "Lavatory Faucet" Article.
4. Water-Temperature Limiting Device: Comply with requirements for temperature-actuated, water mixing valves specified in Section 22 11 19 "Domestic Water Piping Specialties" and as scheduled on Drawings.
5. Supplies: Comply with requirements in "Supply Fittings" Article.
6. Drain: Offset Tailpiece. Comply with requirements in "Drain" Article.
7. Trap: Standard Trap. Comply with requirements in "Trap" Article.
8. Support: Comply with requirements in "Support" Article.

2.3 MANUALLY OPERATED LAVATORY FAUCETS

- A. Lavatory faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372, or be certified in compliance with NSF 61/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.
- B. Lavatory Faucets: Manual-type, two-handle metering, centerset commercial, solid-brass valve.
 1. Basis-of-Design Product: 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. Chicago Faucets; MVP Commercial Faucet No. 802-V665CP.
 - b. Delta Faucet Company; Commercial Faucet No. 86T1153.
MOEN M-PRESS COMMERCIAL FAUCET NO. 8886.
 - c. Zurn Industries, LLC; Commercial Brass and Fixtures; AquaSpec Faucet No. Z86500.
 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 fixture receptor.

4. Body Type: Centerset, with 4" centers.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow: 0.25 gal. per metering cycle.
8. Mounting Type: Deck, exposed.
9. Valve Handle(s): Push button.
10. Spout: Rigid type.
11. Spout Outlet: Aerator.
12. Operation: Compression, manual.

2.4 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 61 and NSF 372 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., 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: Basis-of-Design: No. LFHST02LKSB chrome-plated-brass, compression valve with inlet connection matching supply piping.
 1. Operation: Loose key.
- F. Risers: ASME A112.18.6/CSA B125.6, braided-stainless steel, flexible hose riser.
 1. NPS 3/8.

2.5 DRAINS

A. Offset Tailpiece:

1. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc.; No. 155-WC or comparable product by one of the following:
 - a. American Standard America
 - b. Zurn Industries, LLC; Commercial Brass and Fixtures.

B. Standard: ASME A112.18.2/CSA B125.2.

C. Drain: Grid type with NPS 1-1/4 tailpiece.

2.6 TRAPS

A. Standard Trap:

1. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc.; No. 8902-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 swivel elbow, 17 gauge brass tube to wall with cleanout plug. Include chrome-plated brass escutcheon with set screw.

2.7 LAVATORY SUPPORTS

A. Lavatory Carrier:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg Co; a division of Morris Group International; Series No. 700-M31 or a comparable product by one of the following:
 - a. MIFAB, Inc.
 - b. WATTS; A Watts Water Technologies Company.
 - c. Zurn Industries, LLC.
2. Standard: ASME A112.6.1M.

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 lavatory installation.
- B. Examine counters and walls for suitable conditions where lavatories 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 lavatories level and plumb in accordance with roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Measure support height installation from finished floor, not structural floor.
- D. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
- E. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
- F. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, in accordance with ICC A117.1.
- G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
- H. Seal joints between lavatories, counters, 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."
- I. Install protective shielding enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

3.3 PIPING CONNECTIONS

- A. Connect fixtures 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. Comply with “Field Quality Control” article in Part 3 of Section 22 05 00 “Common Work Results for Plumbing” for lead testing requirements prior to commencing any work.
- B. Inspecting Agency: 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. Submit test results Owner and the Architect.
- C. 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 lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

3.6 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.

END OF SECTION 22 42 16.13

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. Service sinks.
- 2. Sinks.
- 3. Sink faucets.
- 4. Supply fittings.
- 5. 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. Include rated capacities, operating characteristics and furnished specialties and accessories.
 - a. Mop receptor faucet.
 - b. Sink "A" faucet.
 - c. Sink "B" 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. Mop receptor "A".
- 2. Mop receptor accessories.
- 3. Sink "A" bowl.
- 4. Sink "B" bowl.
- 5. Supply Fittings.
- 6. Offset Drain Fitting.
- 7. Sink Traps.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE 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. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

1.7 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. 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.

1.8 FIELD CONDITIONS

- A. Comply with “Project/Site Conditions” article in Part 1 of Section 22 05 00 “Common Work Results for Plumbing” for lead testing requirements prior to commencing any work.
- B. Coordinate potable water lead testing with Owner prior to starting any construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sink faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), 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. Source Limitations: Obtain sink fixtures, faucets and accessories from single source from single manufacturer.

2.2 SERVICE BASINS

A. Mop Receptor (MR “A”): Plastic, floor mounted.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Crane Plumbing, L.L.C.; Fiat Model No. MSB3624 or comparable product by one of the following:
 - a. Ferguson Enterprises, Inc.; ProFlo Brand.
 - b. Florestone Products Co., Inc.
 - c. Mustee, E. L., & Sons, Inc.
 - d. Swan Corporation (The).
 - e. Zurn Industries, LLC; Light Commercial Specialty Plumbing Products.
2. Fixture:
 - a. Standard: CSA B45.5/IAPMO Z124.
 - b. Material: Molded polymer.
 - c. Nominal Size: 36 by 24 by 10 inches.
 - d. Tiling Flange: Not required.
 - e. Rim Guard: On front top surfaces.
 - f. Drain: Stainless steel, flat grid drain body with NPS 3 outlet.
3. Mounting: On floor and flush to wall.

B. Accessories:

1. Faucet: Comply with requirements in “Sink Faucet” Article.
2. Hose and hose bracket; 5 by 3 inches stainless steel bracket with rubber grips. 30 inch long flexible heavy duty 5/8 inch rubber hose, cloth reinforced with 3/4 inch chrome coupling at one end. Similar to “No. 832-AA” by Fiat.
3. Mop hanger bracket; 24 by 3 inches, stainless steel with three (3) rubber grips. Similar to “No. 889-CC.”

2.3 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": Large stainless steel, counter mounted, accessible.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model No. LRAD 3122-55 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: 31 by 22 inches.
- e. Metal Thickness: 18 gauge / 0.050 inch.
- f. Material: Type 304 stainless steel with fully undercoated underside.
- g. Compartment:
 - 1) Dimensions: 28 by 16 by 5.5 inches.
 - 2) Drain: 3.5 inch opening.
 - 3) Drain Location: Centered, near back of compartment.
- 3. Faucet(s): Accessible, manual type, two-lever-handle mixing valve with restricted 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.

2.4 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. Mop Receptor Faucets: Manual type, two-lever-handle mixing valve.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Speakman Company: Model No. SC-5811 or comparable product by one of the following:
 - a. Chicago Faucets.
 - b. Delta Faucet Company.
 - c. GROHE America, Inc.
 - d. Just Manufacturing.
 - e. Moen Incorporated.
 - f. T & S Brass and Bronze Works, Inc.
 - g. Zurn Plumbing Products Group.
 - 2. Standard: CSA/ASSE-1001.
 - 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: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 10 gpm hot- and cold-water full open at 40 psig
8. Handle(s): Cross, four arm.
9. Mounting Type: Back/wall, exposed.
10. Spout Type: Rigid, solid brass with wall brace.
11. Vacuum Breaker: Required for hose outlet.
12. Spout Outlet: Hose thread according to ASME B1.20.7.
13. Integral Stops: Required.

C. 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: 1.5 gpm.
8. Handle(s): Lever.
9. Mounting Type: Deck, exposed.

10. Spout Type: Swing, shaped tube.
 11. Spout Outlet: Aerator.
- D. Sink Faucets: Manual type, two-lever-handle mixing valve with restricted swing spout.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Manufacturing Co; Model LKD2439C 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): Accessible levers.
 9. Mounting Type: Deck, exposed.
 10. Spout Type: Restricted swing (45° each side of center), round tubular arc spout. Requires spout kit #000000685.
 11. Spout Outlet: Aerator.

2.5 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.

2.6 DRAINS

- A. 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.

2.7 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 water-supply piping with stop on each supply to each sink faucet. Install stops in locations that are accessible for ease of operation.
- D. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
- E. Set floor-mounted sinks in leveling bed of cement grout.
- F. 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."
- G. 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. Comply with "Field Quality Control" article in Part 3 of Section 22 05 00 "Common Work Results for Plumbing" for lead testing requirements prior to commencing any work.
- B. Inspecting Agency: 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. Submit test results to the Owner and the Architect.
- C. 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 47 16 - PRESSURE WATER COOLERS

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. Pressure water coolers.
 - 2. Bottle filling stations.
 - 3. Supports.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pressure water cooler and bottle filling station include construction details, material descriptions, dimensions of individual components and profiles, finishes, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 1. Surface Wall-Mounted, Stainless Steel.
 - 2. Supply fittings.
 - 3. Traps.
- B. Shop Drawings:
 - 1. Include diagrams for power wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pressure water coolers and bottle filling stations to include in maintenance manuals.

1.5 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.

1.6 FIELD CONDITIONS

- A. Refer to the "Project/Site Conditions" article in Section 22 05 00 "Common Work Results for Plumbing" for lead testing requirements prior to commencing any work.
- B. Coordinate potable water lead testing with Owner prior to starting any construction.

1.7 MAINTENANCE 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. Filter Cartridges: Equal to 5 percent of quantity installed for each type and size indicated, but no fewer than 2 of each.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Standards:
 - 1. Pressure water coolers and bottle filling stations intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or 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.
 - 2. Comply with ASHRAE 34 for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
 - 3. Comply with UL 399.
 - 4. Comply with ASME A112.19.3/CSA B45.4.
 - 5. 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.
 - 6. Comply with NSF 42 and NSF 53 for water filters for water coolers and bottle filling stations.
 - 7. Comply with ICC A117.1 for accessible water coolers and bottle filling stations.

2.2 PRESSURE WATER COOLERS

A. Pressure Water Coolers - Surface Wall-Mounted, Stainless Steel: (EWC “A”).

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay; Model No.LZS8WSSK with Model 51299C Lead + Microplastics Filter or a comparable product by one of the following:
 - a. Halsey Taylor.
 - b. Murdock Manufacturing; A Division of Morris Group International.
 - c. Oasis International.
2. Source Limitations: Obtain surface wall-mounted, stainless steel, pressure water coolers from single source from single manufacturer.
3. Cabinet: Single, all stainless steel.
4. Bubbler: Abrasion-resistant, anti-sweat, pliable polyester elastomer with infused anti-microbial, keyed in location to prevent rotation, with adjustable stream regulator, located on cabinet deck.
5. Control: Push bar on front and sides.
6. Bottle Filling Station: Stainless steel construction with ABS plastic alcove and the following features:
 - a. Electronic sensor for touchless activation with auto 20-second shut off.
 - b. Filling Rate: 1.1 gpm.
 - c. Laminar flow to minimize splashing.
 - d. Integral drain to eliminate standing water.
 - e. LED visual filter monitor to indicate when filter requires replacement.
7. Drain: Grid with NPS 1-1/4 tailpiece.
8. Supplies: Comply with requirements in “Supply Fittings” Article.
9. Trap: Comply with requirements in “Trap” Article.
10. Filter: NSF/ANSI Certified filter designed to reduce lead, particles and chlorine.
 - a. Tested and certified to NSF 42 and 53 for lead, Class 1 particulate, chlorine taste and odor reduction.
 - b. Tested and certified to NSF/ANSI 401 for the reduction of microplastics.
11. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

B. Supports

1. Support: Manufacturer's support frame attached to substrate.
2. Capacities and Characteristics:
 - a. Cooled Water: 8 gph.
 - b. Ambient-Air Temperature: 90 deg F.
 - c. Inlet-Water Temperature: 80 deg F.
 - d. Cooled-Water Temperature: 50 deg F.
 - e. Electrical Characteristics:
 - 1) Motor Horsepower: 1/5.
 - 2) Volts: 120 V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60 Hz.
 - 5) Full-Load Amperes: 6 A.

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. LFBV07-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 3/8.
 2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.4 TRAPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide McGuire Manufacturing, Inc. No. 8872C-F or comparable product by one of the following:
 - 1. American Standard America.
 - 2. Zurn Industries, LLC; Commercial Brass and Fixtures.
- B. 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.
- C. Standard: ASME A112.18.2/CSA B125.2.
- D. Size: NPS 1-1/4 by 1-1/4.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- C. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers, and bottle filling stations to mounting frames.
- D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping.
- E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
- G. Seal joints between fixtures 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."

3.3 PIPING CONNECTIONS

- A. Connect fixtures 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. Install ball shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 22 05 23 "General Duty Valves for Plumbing Piping"
- D. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.5 FIELD QUALITY CONTROL

- A. Inspecting Agency: Engage a qualified laboratory to perform lead testing on all potable water fixtures installed under this contract and used or potentially used for drinking or cooking purposes according to NYS Law 10 CRR-NY 67-4.1.
- B. Replace any drinking fountain that exceeds the lead action level (5 micrograms per liter) and coordinate with the Owner for retesting until satisfactory results are obtained.

3.6 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust pressure water-cooler temperature settings.

3.7 CLEANING

- A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 47 16

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. Mechanical penetrations, waterproofing, and sealants.
 - 11. Fire-stopping
 - 12. Access doors
 - 13. 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. IEEE Institute of Electrical and Electronics Engineers, Inc.
 - 10. NEC National Electric Code
 - 11. NEMA National Electrical Manufacturers Association
 - 12. NFPA National Fire Protection Association
 - 13. SMACNA Sheet Metal and Air Conditioning Contractors National Association
 - 14. 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, including all system fluid and solid components.
 2. Piping systems and related equipment.
 3. Refrigeration systems and related equipment.
 4. Ventilation systems and related equipment.
 5. Support Systems and related equipment.
 6. Insulation Systems and related equipment.
 7. Miscellaneous items required for equipment and system installation.
 8. Controls and electrical control wiring to equipment furnished in this contract.
 9. 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 "Submittal Procedures" 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 Procedures") 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 not 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. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - 1. Sealants
 - 2. Fire-stopping.
 - 3. Access doors.
- D. Samples:
 - 1. Submit color chart with paint manufacturer’s color samples for final color selections prior to beginning painting. Comply with additional requirements for color selection samples specified in Division 09.
- E. 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, 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 be 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.

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 coils, valves, traps, 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. New Construction:
 - 1. Obtain and furnish necessary information, such as locations and sizes of heating construction, fixtures and equipment, to all Contractors in ample time for installation of openings, chases, recesses, lintels and bucks required for admission of project construction, fixtures and equipment.
 - 2. Provide sleeves, inserts, panels, raceways, boxes, and similar components, ahead of schedule required for Heating Work installation and ahead of associated General Work. Provide Heating Work representative during installation of General Work responsible for maintaining items in position.
- D. 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.
- E. 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.
- F. 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 installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- E. 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.
- F. Notify Architect in case of unresolved interferences prior to installation of Heating Work.
- G. Adjust exact size, location and offsets of exposed HVAC components to achieve reasonable appearance objectives without increase in Contract Sum.
- H. 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 warranty 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. Provide electrical equipment and systems meeting UL standards and requirements of NEC.
2. Provide UL label on all equipment and material with listing service.

3. Material Flammability:
 - a. Flame spread rating of 25 or less.
 - b. Smoke developed rating of 50 or less.
4. 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.

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 ACCESS DOORS

- A. Comply with requirements for access doors specified in Section 08 31 13 "Access Doors" and Frames for product requirements of access doors in general construction.
- B. Comply with requirements for access doors specified in Sections 23 31 00 "Ductwork" and 23 33 00 "Ductwork Accessories" for product requirements of access doors in Air Ducts.

PART 3 - EXECUTION

3.1 EXISTING CONDITIONS

- A. Examine existing conditions in the field prior to beginning demolition or contract Work as required to confirm conditions are appropriate for the work to proceed. Refer to Section 01 73 00 "Execution" and Section 02 41 19 "Selective Demolition" for additional information and general demolition requirements and procedures.
- B. 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.
- C. 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.

3.2 HVAC DEMOLITION

- A. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Prior to removal of system components, provide for proper working conditions including but not limited to:
 - a. Electrically shutdown and/or disconnect with lockout / tag as required.
 - b. Provide Personnel Protection Equipment.
 - c. Air Systems: seal off portions of systems not under construction as required protecting Owner's belongings.
 - d. Hydronic Systems: Properly isolate and drain systems as required protecting Owner's belongings.
 - e. Refrigerant Based Systems: Evacuate and retain refrigerant per ASHRAE 15 and 40 CFR 82.
 - 2. 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.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and cap remaining ducts with same or compatible ductwork material.
 - 4. Equipment to Be Removed: Disconnect and remove equipment and all associated accessories. Plug, cap, seal, and otherwise patch to match as required.

B. 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 turned over to the Owner: deliver to a project site location designated by the Owner.
4. 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.
5. 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.

3.3 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 final condensate, heating water, drain, vent, refrigerant, connections to all equipment as required.
 2. 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.
 3. Provide equipment waste, drip, overflow, condensate, and drain connections extended to floor or roof drains or other approved points of discharge. Provide integral condensate pumps and appropriate piping for units where gravity condensate drain is not practical or possible.
 4. Connect equipment complete and ready-to-use, including all valves, piping, piping accessories, traps, gauges, 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 48 "Mechanical Wind Load 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, or acoustical noise reduction rating. Ensure 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.

3.7 PROTECTION

- A. 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 warranties.
- 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. 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.
 - d. Air conditioning units and 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. 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 accessories for electric motors.
 - 3. Electrical auxiliary components required for HVAC systems that are not specifically identified in "Electrical" 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, 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 constant speed motors 1/3 HP and smaller designed for operation on single phase, 120 volts +/- 10 percent.
- E. Comply with NEMA MG 1 unless otherwise indicated.
- F. 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, damp, high humidity, or condensing 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.

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.

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. Test plugs.
 - 2. Test-plug kits.

1.3 SUBMITTALS

- A. Procedural Requirements: Comply with requirements of Section 01 33 00 "Submittals Procedures" 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 Procedures") 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 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 test plugs in piping tees in location that allows for ease of insertion of standard test kit probes.
- B. Assemble and install connections, tubing, wiring, and accessories between flow-measuring elements, flowmeters and their controllers, and integrate with Energy Management and Control System as specified and as shown, all in accordance with manufacturer's written instructions.

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 and as noted on the drawings.

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. Automatic Flow Control Balancing valves.
 - 3. Manual Balancing Valves
 - 4. 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 “Submittal Procedures” 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 “Submittal Procedures) 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. 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 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.
 3. Set ball valves open to minimize exposure of functional surfaces.
- 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.

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.
- F. Valve-End Connections:
 - 1. Solder Joint: With sockets according to ASME B16.18.
 - 2. 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.

2.3 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 ½ 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. Each valve shall have two P/T test plugs.
- E. Construction:
 - 1. For ½” 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.
- F. 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.
- G. Design Make: IMI Flow Design Inc.

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, ¼-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 ½-inch to 2-inches inclusive.
 - 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 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. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. Install isolation valves with unions at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- 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.

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
- C. Flow Adjustment and Balancing:
 - 1. Provide line size manual adjustment balancing valves for service on terminal units scheduled for 1 GPM flow or less.
 - 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.
- D. Hydronic System Drain Service: Provide drain valves at all low points as required for complete system drainage.
 - 1. 2 inch and smaller service: Provide $\frac{3}{4}$ inch full port ball or globe valves, with $\frac{3}{4}$ 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; 1/2" NPT on 4" and larger piping.
 - 2. Equipment Air Vents:
 - a. Provide High Capacity Automatic Air Vent above each air and air/solids separator.
 - b. Boilers: Provide High Capacity Automatic Air Vent.

3.4 VALVE INSTALLATION

- A. When installing solder-joint end valves, protect valve body from soldering heat using water soaked rags or other heat sink method as required to avoid valve damage. Leaking stems or seats on solder-joint end valves shall be subject to immediate replacement with new valve.
- 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 and handle movement.

- E. Install all Automatic Air Vents above manual vent assembly described below, with discharge piped to point of collection - for glycol venting, pipe discharge to glycol feed station as shown, or if not shown to minimum 1 quart clear plastic container, secured and removable for service.
 - 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 curb assembly
 - c. Equipment support rails
 - d. Pipe and duct supports

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. 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, in crawl spaces, manholes, pits, and below grade: 300 series stainless steel or post-fabrication (after forming, welding, drilling, etc.) ASTM A-153 hot dipped galvanized steel, minimum coating thickness 3 mils.
5. Miscellaneous fabricated custom supports, anchor bases, etc.: painted in accordance with Section 23 05 00 "Common Work Results for HVAC".
6. Other special conditions: where noted on drawings, provide materials of special temperature, corrosion resistance, or other properties, as required for durable and safe performance.

B. 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.

C. 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.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

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. Miscellaneous components

B. Shop Drawings: Submit intended custom support construction for approval.

C. 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.

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.

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. 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. 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. 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.

E. 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.

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. 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.; Lehigh, Pennsylvania, or equal.
- d. Buckaroos, Inc.

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.

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. 14 inches for curbs supporting exhaust and relief air equipment.
 - b. 24 inches for curbs supporting intake of fresh 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. Pipe Curb Assembly: Similar to Roof Curb specified above, equipped with fully welded curb cap top cover of heavy gauge aluminum (12ga), galvalume (16ga), or stainless steel (16ga) construction with integral curb counter flashing, raised flashing collars with replaceable neoprene pipe boot counter flashing secured with stainless steel clamps, size and number of pipe and conduit openings as required. Similar to Pate PCA curb with PCC-C custom curb cap package.
 1. Provide products by one of the following:
 - a. Pate or equal
 - b. Con-Fab or equal
 - c. Thy-Curb or equal

- C. Equipment Support Rails: Double shell galvanized steel, 14 gauge minimum, fully welded with solid bottom and ends. 2 inch x 8 inch treated wood top blocking, minimum 12 inches high above finished roof, minimum 2 inch turned out flange at bottom, C-channel top cap counter-flashing over blocking. Length to be the longer of 12 inches longer than equipment served or extended past equipment to next building structural support member, factory certified for weight of intended equipment at spacing of structure below, with reinforcement and heavier gauge as required. Units longer than eight feet may be field spliced with bolts and splice plates. Provide galvanizing paint at welds and field splices. Include top cap and integral base with raised cant where required. Provide flanged curb bottom to suit roof construction and insulation.
 1. Similar to custom "ES-5A" by Pate.
 2. Provide products by one of the following:
 - a. Pate or equal
 - b. Con-Fab or equal
 - c. Thy-Curb or equal

- D. 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 two pounds per square foot. 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

E. 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 two pounds per square inch. 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. 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

F. Portable Pipe Hangers (PHP) Systems and Design, Houston, Texas, or equal

2.6 EQUIPMENT SUPPORTS

- A. Provide custom designed hangers and supports to properly and resiliently support all contract equipment as required by special circumstances encountered. Suspend from above or support from below as shown on drawings and as required.
- B. Use structural carbon steel plate and shapes, secured by welding or bolts as required.
- C. Use load rated fasteners full size of the component attachment points unless specifically requested and approved otherwise.
- D. Provide lateral bracing as required minimizing potential for sway.
- E. Fabricate as required to transmit loads and reaction forces to structure, in accordance with applicable details and layouts shown on Drawings, and as approved by Architect. Submit load calculations and fabrication details for approval for all such supports including verified coordinated dimensions, weights, etc., of mechanical component, support component, and building structure proposed.

2.7 MISCELLANEOUS COMPONENTS AND ACCESSORIES

- A. 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. 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 inch lateral movement in a 12 inch 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 inch lateral movement in a 12 inch rod), provide pipe roll.
- 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:

<u>Piping Material</u>	<u>Maximum spacing of hangers</u>
a. PVC and CPVC ¾ in. and smaller	3 ft
b. PVC and CPVC 1 in. and 1-¼ in	4 ft
c. Copper ¾ in. and smaller	5 ft.
d. Copper 1 in. and 1-¼ in.	6 ft.

3.4 ROOFTOP SUPPORT INSTALLATION

A. Rooftop Supports for Piping and Ductwork:

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. Attach supports to roof as required for wind, and thermal movement control with compatible rooftop fasteners through holes drilled in bottom of pipe stand pitch pan at time of installation. Fill pitch pan with asphalt material or cement as directed to seal areas around fasteners watertight.
- c. Center supports beneath pipe so cradle allows pipe to be squarely over and through cradle pipe stand.
- d. Adjust to desired height insuring level platforms, level horizontal bars, proper longitudinal pitch for pipe and duct, and even load distribution among all supports.
- e. Set equipment in support without dropping or causing undue impact. Assemble platform grating and secure to superstructure.
- f. Assemble piping restraints and make final adjustments to alignment and level.

B. Roof Curbs, Pipe Curbs, and Equipment Support Rails:

1. Maintain existing roof warranties. Contractor is responsible for the installation of all Roof Curbs, Pipe Curbs, and Equipment Support Rails 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 wind restraint system. Provide tapered shims as required up to 3-1/2 inches thick. If structure slopes more than 3-1/2 inches 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. Coordinate in curb access and rooftop equipment sound transmission mitigation:
 - 1) Coordinate roof deck removal within curbs in all cases with Architect, Owner, Construction Manager and all affected trades as required to optimize access and sound transmission prevention.
 - 2) Coordinate special circumstances requiring exceptions to above with Architect and equipment manufacturers.
 - g. 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.

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.
- b. Catalog cuts and data sheets on components used. Indicate style, material, and attenuation characteristics for each device or product.
- c. Schedule of flexibly mounted equipment, referencing drawings by number. Include number, type, and loading of all isolation components.

C. Informational Submittals:

1. Product Certificates:

- a. Contractor Statement of Responsibility: Refer to Division 01 Section, "Quality Requirements."

2. Welding certificates.

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 QUALITY ASSURANCE

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

1.7 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. Factory Finishes: Provide manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation devices to indicate capacity range.
- C. 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.
- D. Isolation Mountings
 - 1. Neoprene Mountings: Provide minimum static deflection of 0.35-inch with all metal surfaces neoprene-covered and having friction pads both top and bottom.
 - a. Bolt holes provided on base, isolated from tapped bolt hole with cap screw on top.
 - b. Steel frame bases used above mountings to compensate for overhang.
 - c. Basis-of-Design Product: Mason Industries, Inc.; Type ND or Rails Type DNR.
 - 2. Restrained Neoprene Mountings: OSHPD pre-approved vibration isolation mounts with captive opposed neoprene inserts, minimum static deflection of 0.2-inch.
 - a. Restraint rated at 2G minimum in all directions.
 - b. Plated steel frame with base mounting holes, isolated from tapped bolt hole with cap screw on top.
 - c. Basis-of-Design Product: Mason Industries, Inc.; Type BR.
- E. 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.
2. Type A Hangers: Rigid steel frames containing minimum 1-1/4-inch thick neoprene elements at top and steel spring with general characteristics as specified for Spring Isolator above seated in steel washer reinforced neoprene cup on bottom.
- a. Neoprene element and cup have neoprene bushings projecting through steel box.
 - b. Boxes not articulated as clevis hangers nor neoprene element stacked on top of spring in order to maintain stability.
 - c. Spring diameters and hanger box lower hole sizes large enough to permit hanger rod to swing through 30-degree arc from side-to-side before contacting cup bushing and short-circuiting spring.
 - d. Include hanger drawing showing 30-degree capability.
 - e. Basis-of-Design Product: Mason Industries, Inc.; Type 30N.

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 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 23 05 43

SECTION 23 05 48 – MECHANICAL WIND LOAD 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 control of mechanical component movement resulting from wind generated loads. 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 are included.
- B. Considering that the basis of design equipment is not always provided for project work, and that not all acceptable "equals" are the same weight, size, center of mass, cross section profile, and other characteristics that affect the wind load calculations, these detailed calculations are to be performed once specific to the approved mechanical equipment as part of a delegated design as detailed below.
- C. Control of mechanically generated vibrations and sounds and control relative movement of components due to thermal expansion and contraction are covered in Section 23 05 43 "Mechanical Vibration and Movement Control".
 - 1. Securing those vibration and movement control components against wind loads is covered in this section.
- D. Specialized movement control components specified in this section include:
 - 1. Wind restraints and snubbers.
 - 2. Wind restraint construction requirements.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the wind loads specified."
- D. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the wind loads specified and the unit will be fully operational after the wind event."
- E. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 RESTRAINT PERFORMANCE REQUIREMENTS

- A. Provide restrained 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. Coordinate restraints with vibration and movement control system described in section 23 05 43 "Mechanical Vibration and Movement Control".
- B. Provide complete design, detailing, and design documentation of all wind restraints required and exceptions allowed, 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, allowing all restrained components to withstand wind load specified. Design shall be performed by a qualified licensed and registered professional engineer, with all drawings, calculations, and design analysis data signed and sealed by the engineer responsible for their preparation.
- C. Design in accordance with the mechanical component wind design requirements of the Building Code of New York State and applicable local codes. Calculations and design to be based on the following criteria.
- D. Wind-Restraint Loading:
 - 1. Basic Wind Speed: 90 mph
 - 2. Building Occupancy Category: III.
 - 3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.5 SUBMITTALS

- A. General: Submit all action submittals and informational submittals required by this Section concurrently.
- B. 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 wind load 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 WIND LOAD RESTRAINT DEVICES

- A. Wind load restraint devices may include all wind restraint devices listed above as approved and as included in the delegated design wind restraint calculations submittal, as well as any other custom wind restraint devices designed and approved by delegated design engineer which are required above and beyond specified wind restraint system.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive wind 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 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 WIND RESTRAINT INSTALLATIONS

- A. General Wind Restraint Requirements:
 - 1. Provide complete wind restraint system as specified and as shown and detailed on approved delegated design submittals.
 - 2. Install restraint devices in strict accordance with the approved Installation Quality Control Procedure and other applicable submittal data, using methods approved by an evaluation service member of ICC-ES, OSHPD, or required submittals for component.
 - 3. Strength of Support and Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and wind loads within specified loading limits.
 - 4. Install cables so they do not bend across edges of adjacent equipment or building structure.

B. Equipment Restraints:

1. Snubbers: Install the required number of snubbers on each spring-mounted piece of equipment. Locate snubbers as close as possible to the vibration isolators and bolt to equipment base and supporting structure.
2. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolts and mounting hole in concrete base.
3. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
4. Vibration Isolation Bases: Mount equipment on structural-steel bases or concrete inertia bases.

C. Piping Restraint:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c., or closer as detailed in delegated design.
3. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.
4. Brace at change of direction longer than 12 feet.

D. Structural Attachments:

1. All welding shall be by qualified welders using qualified procedures.
2. If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
3. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
4. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
5. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
6. Set anchors to manufacturer's recommended torque, using a torque wrench.
7. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust air-spring leveling mechanism.
- D. Adjust active height of spring isolators.
- E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.4 FIELD QUALITY CONTROL

- A. Contractor Requirements:
 - 1. Testing Agency: Engage the services of a qualified Testing Agency to perform Tests and Inspections.
 - 2. Provide access to all places of inspection for representatives Testing Agency(s).
 - 3. Schedule tests with Owner's Project Representative, and Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
 - 4. Obtain Architect's approval before transmitting test loads to the structure. Provide temporary load-spreading members as required by the test loads.
 - 5. Perform the following Tests and Inspections:
 - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - b. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - c. Test to 90 percent of rated proof load of device.
 - d. Measure isolator restraint clearance.
 - e. Measure isolator deflection.
 - f. Verify snubber minimum clearances.
 - g. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
 - h. Prepare test reports and distribute to Owner and Architect.
 - 6. Remove and replace malfunctioning units and retest as specified above.
- B. Remove and replace malfunctioning units and retest as specified above.

- C. Walk-through with Owner's Project Representative, Professional Engineer responsible for design of wind restraints, and Restraint Manufacturer's Representative to verify installation is in accordance with specifications and submittals. Provide manufacturer approval letter and Professional Engineer-stamped letter documenting installation is complete and approved by them as in compliance with Project requirements.
- D. Owner's Testing Agency: Will perform inspections and tests as required by applicable codes and insurance regulations. Make any corrections as required to meet Owner's Testing Agency's requirements.

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION 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. Equipment labels.
 - 2. Pipe labels.
 - 3. Duct labels.
 - 4. Valve tags.

1.3 SUBMITTALS

- A. Procedural Requirements: Comply with requirements of Section 01 33 00 "Submittal Procedures" 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 "Submittal Procedures") 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 manufacturer's data sheets for all proposed products demonstrating compliance with specifications.
- 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 identification components used.
 - 2. Include all information required in Section 01 78 23 "Operation and Maintenance Data".
 - 3. Valve Chart - Refer to Section 23 05 00 "Common Work Results for HVAC", for details.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Paint: Refer to Division 09.
- 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. Brimar Industries, Inc. or equal.
 - 2. Campbell International (Ltd.), or equal.
 - 3. Craftmark Identification Systems, Fort Worth, Texas, or equal
 - 4. EMED Company, Inc., Buffalo, New York, or equal
 - 5. Seton Name Plate Company, New Haven, Connecticut, or equal

2.2 LABELS

- A. Equipment Labels:
 - 1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware, or multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 3. Colors:
 - a. Brass Labels: black in-filled letters on brass background
 - b. Plastic Labels: white letters on black plastic background
 - c. Warning Signs: yellow letters on black background.
 - 4. Able to withstand temperatures up to 160 deg F. continuously.
 - 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 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.
- B. Equipment Label Content: Include equipment's Drawing designation or unique equipment number and equipment function.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Include Equipment Schedule in Operation and Maintenance Manual.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive. Secure in place with full circumference tape wrap.
- C. Pipe Label Contents: Include identification of piping service using abbreviations indicated below, pipe size, and an arrow indicating flow direction.
 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction (flow direction arrow circumference tape preferred).
 2. Lettering Size: In accordance with ANSI 13.1 and as follows:

Outside diameter:	Letter Height:
a. 2" or less	3/4"
 3. Pipes too small to be directly labeled: provide hanging equipment tag with 1/2" lettering. Outside diameter indicated is to outside of pipe insulation on insulated piping.
- D. Piping Systems: Identify the following systems as indicated:
 1. Refrigerant Liquid (RL)
 2. Refrigerant Suction (RS)
 3. Heating Hot Water Supply (HWS)
 4. Heating Hot Water Return (HWR)
 5. Condensate Drain (CD)

2.4 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Colors: Letter color, black; background color, white.

- C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. Minimum Letter Size: One inch for viewing distances up to 60 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- F. Fasteners: Stainless-steel rivets or self-tapping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.5 VALVE TAGS

- A. Valve and Hydronic Specialty Identification: Provide 1-1/2-inch diameter brass tags, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment with #16 brass jack chain, factory engraved or stamped with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with black in fill, legend as described below.
 - 1. Stamp "H" and valve number for each main, riser, zone, and branch heating valve.
 - 2. Provide manufacturer's tags for all automatic balancing fittings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.
- B. Beginning installation constitutes Contractor's acceptance of substrates and conditions.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE IDENTIFICATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. Near major equipment items and other points of origination and termination.
5. Spaced at maximum intervals of 15 feet along each run.
6. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.4 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. Near major equipment items and other points of origination and termination.
 5. Spaced at maximum intervals of 15 feet along each run.
 6. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule:

<u>Item</u>	<u>Color</u>
1. Refrigerant.....	Dark Green
2. Hot water supply & return.....	Red
3. Condensate (drain).....	Rust Brown

3.5 DUCT LABEL INSTALLATION

- A. Stenciled Duct Label Option: Stenciled labels, showing service, size, and flow direction as indicated above, may be provided instead of plastic-laminated duct labels, at Installer's option, for concealed ductwork or if lettering larger than 1 inch high is needed for proper identification because of distance (over ten feet) from normal location of required identification. Stencils shall be crisp and neat with no overspray, drips, runs, or other imperfections visible from normal viewing distance. Refer to Division 09 sections on painting for more information.
- B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on new valves, hydronic specialties, and control devices in piping systems. Verify existing valve numbers in field and provide valve numbering avoiding duplication of existing numbers.
- B. Valve Identification Chart: Refer to Section 23 05 00 "Common Work Results for HVAC" for Valve Identification Chart requirements.

END OF SECTION 23 05 53

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. Perform no work affecting TAB prior to TAB Agency approval and submission of Pre-Construction Inspection and Testing Report.
2. Prior to submittal of any equipment affecting TAB, review with approved TAB Agency and obtain commentary and approval as described in "Summary" Article. Include TAB Agency review commentary with affected submittals.
3. 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. Within 30 days after award of Contract, submit TAB Agency qualifications proposal for approval.

B. Contractor and TAB Agency:

1. Submit Systems Readiness Reports as described more fully below.

C. 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, Evidence of current TAB Agency and TAB Supervisor Certification, Examples of data forms proposed for each system type showing input cells for this Project's required data, 3 regional references for comparable recent jobs.
 - c. List of instruments to be used in testing and balancing, with current certification of all instruments' calibration on calibration agency letterhead, including the following information:
 - 1) Instrument type and make.
 - 2) Serial number.
 - 3) Application.
 - 4) Dates of use.

- 5) Dates of calibration.
 - 6) Test data points over range qualified – standards and measured values.
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. TAB Agency:

1. 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.
2. Include commentary with all Contractor submittals affecting TAB work as described above.
3. 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 Conference: After approval of the TAB Strategies and Procedures Plan and before TAB Work begins, schedule and attend a meeting with Architect, and Construction Manager, at their convenience, to develop a mutual understanding of the details. Require the participation of the TAB Field Supervisor and Technicians. Provide seven days' advance notice of scheduled meeting time and location.
1. Agenda Items:
 - a. Review the Contract Documents examination report.
 - b. Review the TAB Strategies and Procedures Plan.
 - c. Review the System Readiness Report.
 - d. Coordination and cooperation of trades and subcontractors.
 - e. Coordination of documentation and communication flow.
- D. TAB Report Data Forms: Follow AABC, NEBB, TABB, or SMACNA format as modified by the data requirements of this Project, subject to submittal approval.
- E. 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.
- F. 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".
- G. 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. Coordinate with Temperature Controls Contractor to manipulate HVAC systems as required to simulate design conditions for load testing boilers, chillers, terminal load equipment, and similar portions of the systems.
- 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:

- a. 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 report delivered at minimum two calendar weeks prior to contract scheduled Substantial Completion Dates.
- b. 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.
- c. For phased projects prepare phased partial readiness for TAB coordinated with TAB Agency as required meeting the Owner's construction schedule.
- d. Coordinate and report partial systems readiness in writing to TAB agency, Construction Manager, and Engineer, to allow TAB work to proceed in an orderly fashion.

2. TAB Agency:

- a. 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 Dates.
- b. 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 one calendar week of partial phased work readiness and 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, Owner, Architect/Engineer, Construction Manager, and Commissioning Agent. 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, sound meters, 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 and submit a TAB plan that includes the following
 - a. Site specific strategies narrative and step-by-step procedures with this project's equipment identified.
 - b. Instrumentation to be used.
 - c. Forms with specific identification for all equipment.
2. Prepare and submit a blank master Systems Readiness Report to Engineer, Commissioning Agent, and Contractors, with itemized checklists for each individual item to receive TAB Work as appropriate for the equipment, with a column for Contractor indicated status and another two columns with room for TAB Agency and Commissioning Agency commentary itemizing deficiencies discovered and confirming all systems preparation and examination has been properly performed. Include, at minimum, the following checks for each piece of equipment as applicable:
 - a. Air side:
 - 1) Verify required leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - 2) Duct systems are complete with terminals installed.
 - 3) Volume, smoke, and fire dampers are open and functional.
 - 4) Automatic control system dampers are installed, adjusted, and operational, with actuators installed.
 - 5) Manufacturer's startup checklists have been appended.
 - 6) Clean filters are installed, temporary media obstructions are available.
 - 7) Fans are operating, free of vibration, and rotating in correct direction.
 - 8) Variable-frequency controllers' startup is complete and safeties are verified.
 - 9) Ceilings are installed.
 - 10) Windows and doors are installed.
 - 11) Suitable access to balancing devices and equipment is provided.

b. Hydronic and refrigerant piping side:

- 1) Verify leakage and pressure/vacuum tests on distribution systems have been satisfactorily completed.
- 2) Piping is complete with terminals installed.
- 3) Refrigerant systems are properly evacuated and filled with the correct refrigerant at the right pressure.
- 4) Manufacturer's startup checklists have been appended.
- 5) Shutoff and balance valves have been verified to be 100 percent open.
- 6) Pressure gauges, thermometers, and PT plugs are all installed where and as specified.
- 7) Suitable access to balancing devices and equipment is provided.

c. Energy Management and Controls System:

- 1) Pressure, temperature, position, electrical current, and other controls system sensors are installed where and as specified.
- 2) Control valves, dampers, and variable-frequency controllers' are functioning in accordance with the sequence of operation.
- 3) Controllers are installed and functioning in accordance with the sequence of operation.

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, pulleys are aligned and belts properly tight, and equipment with functioning controls is ready for operation. Make any required modifications to systems 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. Permanent electrical-power wiring is complete, and proper thermal overload protection is in place for all electrical equipment.
6. All ductwork, air handlers, grilles, registers, and diffusers are installed, complete, and cleaned of dust and debris.
7. All piping, terminal radiation, valves, required pressure taps, and hydronic specialties are correctly installed, complete, operational, and clean.

8. All ductwork, diffusers and registers have dampers where specified, and all hydronic systems have balancing and isolation valves where specified.
9. Duct system leakage has been tested where required and minimized.
10. Hydronic systems have all required vents and drains installed and functional, and are flushed, vented, cleaned, leak free, and filled with specified heat transfer fluid.
11. All manually set dampers (fire, fire/smoke, register, grille, diffuser, and manual volume dampers) operate smoothly and are adjusted open. All automatic dampers have actuators and required linkages installed and rough adjusted.
12. All hydronic systems valves are installed with proper direction of flow and operate smoothly, balancing valves are adjusted open, P-T plugs and gauges are installed and functional where required, two-way control valves are open, three-way valves are properly installed for their intended function of diverting or mixing fluid flows, and service valves are open or closed as required for normal flow.
13. Make preliminary adjustments to airflow patterns of all registers, grilles, and diffusers to obtain uniform space temperatures and air movement free from objectionable drafts and noise.
14. Clean new final design filters are installed everywhere called for.
15. Coil fins are clean and straight.
16. Access doors in ducts are closed and duct end caps are in place.
17. Access doors necessary to reach duct volume dampers, balancing valves, and measuring stations are installed in accessible locations and are operable.
18. 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.
19. As the various portions of the system are completed and become ready for TAB, prepare and submit partial Systems Readiness Reports to Engineer, Commissioning Agent, and TAB Agency, with itemized checklists filled out as appropriate for the equipment to receive TAB Work, indicating status and requesting TAB for that portion of work commence.
 - a. Include itemized list of all examination and preparation procedures outlined above and as otherwise required by TAB and Commissioning Agencies' 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 any reason, system cannot be properly balanced, report as soon as observed.

20. Report any additional defects or deficiencies observed during performance of TAB procedures.

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. Review, edit, and deliver 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.
3. 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.
4. 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.
5. Take and report testing and balancing measurements in inch-pound (IP) units unless otherwise directed.
6. Promptly report abnormal conditions in mechanical systems or conditions that prevent system balance, for any reason including but not limited to installation, design, or Owner use reasons within 24 hours of discovery.
7. 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.

3.4 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, adjust the fan belt drive system (if applicable) 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-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 - 2. Set terminal units and supply fan at full-airflow condition.
 - 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check flow-control valves for specified sequence of operation, and set at indicated flow.
 3. Set system controls so automatic valves are wide open.
 4. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- B. With the system fully operational, all branch and terminal isolation, balancing, and control valves open, and the pump running at 60Hz/VSD bypass, measure the flow through all terminal units as well as the total system volume, without making any adjustments, and formulate a plan for preliminary balancing valve adjustment. Record and report all initial flow and pressure drop values.

- C. Adjust all manual balancing valves to the proportionally correct gpm, not necessarily the design gpm.
1. If all the valves in a branch line's terminal units must be adjusted to limit gpm, then use the branch line manual balancing or isolation valve to limit the pressure drop across the terminal units in that branch so that at least one terminal unit's balancing valve remains wide open but still has the correct flow. Adjust all other branch lines to proper proportional gpm in this way, leaving the balancing valves in the flow limiting branches wide open.
 2. Provide branch volume control by balancing valves only to the extent that the most open valve remains wide open and adjustments do not create objectionable hydronic sound levels. Under no circumstances shall total system volume be throttled back to design flow through the partial closing of all branch valves.
 3. Record and report all initial adjustment positions and proportional flowrates achieved.

3.9 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the automatic and manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.
- D. Measure and record entering and leaving refrigerant pressures.

3.11 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.

3.12 PROCEDURES FOR EXHAUST HOODS

- A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.
- B. Makeup Air: Insure systems supplying source of makeup air to hoods are in operation during testing and balancing of exhaust hoods.
 - 1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.

2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

C. Kitchen Hoods:

1. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's instructions. Consult hood manufacturer to determine hood airflow using recorded information.
2. Type 2: Measure and record airflow by duct traverse.
3. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Utilize actual cooking or dishwashing equipment where possible. Observe and report performance. Make adjustments to achieve optimum results.
4. Modulating Hood Controllers: Check each hood for proper automatic starting and capture under varying cooking load and smoke generated conditions up to full design cooking load.

3.13 PROCEDURES FOR SPACE AIR PRESSURIZATION BY MECHANICAL SYSTEMS

- A. Before testing and adjusting space pressurization systems, observe each pressurized space to verify construction is complete, including HVAC system, general construction including any firestopping, doors, weatherstripping, etc.. Verify the following:
 1. Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.
 2. Firestopping and sealants are installed.
 3. Doors, door closers, and door gaskets are installed and adjusted.
 4. If applicable, window installation is complete.
 5. HVAC system and associated controls are installed and functioning properly.
 6. Life-safety dampers (smoke or combination fire and smoke) are installed and functioning properly.
- B. Measure and record barometric pressure, wind speed and direction, outdoor-air temperature, and relative humidity on each test day. Proceed with testing and adjusting only on days with none to average wind speed.
- C. Test each enclosure as a single system. If multiple fans serve a single enclosure, operate fans as intended by the design. In rooms with multiple or manual exhaust systems, test under each exhaust fan operating condition.
- D. If a pressurization cascade is required between multiple spaces, for example an egress corridor, a science classroom, and an adjacent chemical storage room, plan and test sequentially as required achieving the required differential between each space.

E. Initial Air Balance:

1. Balance as specified achieving the airflow rates indicated by the design, and measure, adjust, and record the airflow of each outlet and inlet.

F. Pressurization Adjustment

1. Measure the space pressurization differential between the subject space and the adjacent space(s) across each door from the subject space to the adjacent spaces.
2. Adjust the exhaust and supply dampers as required achieving the specified pressure differential.
3. Do not reduce ventilation supply air rates to achieve space pressurization.
 - a. For spaces required to be negative with respect to adjacent space, preferentially increase exhaust airflow.
 - b. For spaces required to be positive with respect to adjacent space, preferentially decrease exhaust airflow.
4. If differential pressure is not indicated on the drawings, adjust as required to achieve a differential pressure between 0.03 and 0.05 inches water gauge with all doors shut and after equilibrium is reached.
5. If the space has no supply air similar to a small custodial closet, adjust the exhaust airflow as specified and measure and report the differential pressure achieved with the door closed.
6. Re-measure and report on the revised airflow rates required to achieve the space differential pressure.
7. Use a spring scale to measure and record the force needed to open all enclosure doors.
8. Repeat this procedure with all different operating configurations of the various automatic and manually operated exhaust systems.
9. Confirm the controls systems function to adjust the associated flowrates as required to maintain the specified differential pressure.
10. If standby power is provided for pressurization systems, test to verify pressurization systems operate while on both normal and standby power.

3.14 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.

3.15 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 minus 10 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. Branch lines and radiation to within 10 percent of the design flow values
 - 2. A total maximum variation of 10 percent between terminal units designated as “typical of (#)”

3.16 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. 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.

3.17 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 and flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Position of balancing devices.
- E. Air Moving Equipment (ERU, UV, F, MUA, CUH):
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 or annotated photograph 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. Include filter pressure drop under clean and partially loaded condition as specified.
 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)
 13. Sound Test Data
- 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).
10. Sound Test Data

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.
 - p. Sound Test Data.

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.
 - h. Sound Test Data.

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)::

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
12. Sound Test Data.

P. Roof Top Hoods, Louvers, Duct Entries:

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. Gauges and Thermometers Reports:

1. Identification/number
2. Location
3. Service
4. Manufacturer
5. Test all gauges and thermometers for mid range accuracy. Adjust thermometers where applicable; adjust all gauges for best 0 and/or midrange accuracy.
6. Temperature, test reading and actual
7. Pressure, test reading and actual

T. Controls Sensors Reports:

1. Coordinate work with Energy Management and Control System.
2. Test all controls system temperature, pressure, air monitoring (CO₂, 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 (CO₂, 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. Air composition, parts per million, test reading and actual. Test and adjust at normal ambient and alarm conditions.

U. Instrument Calibration Reports:

1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.18 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.

3.19 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 jackets.
- i. Tapes.
- j. Securements.
- k. 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.

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.
- C. Coordinate with installation and testing of heat tracing.

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•°F. For pipe and fitting insulation with conductivity other than 0.27 btu•in/hr•ft²•°F, 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•°F.
 - 5) k = specified conductivity, 0.27 btu•in/hr•ft²•°F.
 - b. Hydronic Piping for Heating:
 - 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. Refrigerant Suction Piping:
 - 1) All pipe sizes..... 1 inch
- e. All Variable Refrigerant Flow and Heat Pump Refrigerant Piping:
 - 1) All pipe sizes..... 1 inch
- 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. Refrigerant Piping, Flexible Connections Insulation: fire-resistant, closed cell flexible (elastomeric) foam plastic, similar to Armacell Armaflex with manufacturer’s white painted mastic protective finish.
- 4. Condensate Drain Lines: insulation material similar to rigid pipe or refrigerant piping insulation specified above.

5. 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.
3. Exterior Pipe and Fitting Insulation Protective Jacket: Modified bituminous, aluminum skinned, peel 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 peel 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. 2” nominal size and smaller Strainers, Triple Duty, Autoflow Control, Check, Combination, and Control Valves, 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. $R=6 \text{ deg. F-sq. ft.-h/Btu-in:}$
 - 1) All interior HVAC duct where insulation is required, unless otherwise noted elsewhere.
 - b. $R=12 \text{ deg. F-sq. ft.-h/Btu-in}$
 - 1) Interior outside air intake duct
2. 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.
3. 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”.

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.

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 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.
3. 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.

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:
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 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 existing insulation is damaged as a result of contract work.
 - b. All heating and air conditioning ductwork unless noted otherwise.
 - 1) All heating and air conditioning ductwork 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. 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. 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.
5. 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.
6. 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.

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, 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. Refrigerant Piping Insulation: Install in full accordance with manufacturers specifications and recommendations on refrigerant and condensate lines, using adhesive specifically intended for flexible foam plastic and provided by insulation supplier. Paint all exposed insulation cut ends with manufacturers (white) finish, similar to “WB Armaflex” or equal. Provide preformed elbows and fittings where available and neatly mitered and fit custom fabrications where manufactured components are not available. Tape and seal all joints vapor tight. For exterior refrigerant piping, install exterior piping protective wrapper water and air tight in accordance with manufacturer’s printed installation directions.

5. 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.
- 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. Peeling 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.

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, exhaust systems air-handling units.
 - 2. Terminal and packaged units, including unit ventilators, unit heaters, fan-coil units, finned-tube radiation and packaged units.
 - 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 / Seismic controls for HVAC&R.
 - 2. BAS.
 - 3. Heating-water piping and accessories.
 - 4. Refrigerant piping.
 - 5. Metal ducts and accessories.
 - 6. Fans.
 - 7. Air-handling units.
 - 8. Heat Pumps.
- 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/repared 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 23 05 93 "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 23 05 93 "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 23 05 93 "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. Cooling Generation Systems

1. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested, as required demonstrating that any selected operating performance criteria are met or exceeded.

C. 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.

D. 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.

E. Cabinet Unit Heaters

1. Unit Heater 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 Unit Heater performance certification to the CxA. Unit Heaters 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. The Board of Education of the Waverly School District has decided to purchase controls components, engineering, programming and project management labor from Day Automation Systems Inc, using NYS OGS contract pricing, through NYS OGS Group # 77201, Award # 23150, Contract # PT68783. Products and all other controls system components will in general conform to this specification.
 - 1. State Education Department public bidding requirements include publicly bid installation of standardized equipment purchased by the Owner. Installation of the Energy Management and Control System (EMCS) shall be in full accordance with this specification, by a fully qualified Temperature Controls Contractor (TCC) 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 part of their work. Bid installation shall include both removals of existing controls as specified below and installation of new controls as follows:
 - a. Control Valves and their actuators.
 - b. All control devices: input, output, and logical, including their interface with and mounting in or on piping, sheet metal and general building systems.
 - c. All actuation devices for existing valves and dampers should they be involved.
 - d. All wiring between all EMCS components and all power source wiring for them.
 - e. Removal of all discontinued controls, including but not limited to all pneumatic control air components (piping, compressors, specialties, etc.).
 - 2. Any incidental installations and work not covered above including but not limited to inspecting, testing, and SV acceptance of controls components installation, and controls programming, testing, adjusting, and commissioning labor shall be included in the product portion of this work and shall be provided complete by the state contract vendor, resulting in a complete functional control system per specifications.

- B. 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.
- C. 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.
- D. 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 School District's distributed Day Automation Systems. Accomplish this through the general removal of all existing controls components serving these systems, and providing new controls complete as specified herein. Provide new graphic displays for all new controls, and custom configure graphic displays to meet Owner and Engineer requirements. Provide each of the following portions of the complete EMCS as a standalone system that can communicate with any other Direct Digital Control (DDC) system which is following the same protocol:
 - 1. Operator Work Stations (OWS): Provide one desk top 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.
- E. DDC: Direct Digital Control.
- F. PC: Personal computer.
- G. 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.
- H. 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.
- I. 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.
- J. SCU: Standalone Control Unit, a microprocessor-based controller panel, which contains all necessary control logic to carry out its own, local functions, and can function independently of other SCU panels and all remaining portions of the EMCS. The SCU may serve one or many types of HVAC equipment and is not factory programmed for only one purpose.

- K. 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.
- L. 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.
- M. 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.
- N. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- O. MS/TP: Master slave/token passing.
- P. I/O: Input/output.
- Q. Modbus: a serial communications protocol originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs).
- R. PID: Proportional plus integral plus derivative.
- S. RTD: Resistance temperature detector.
- T. System Modem: a modem which is installed on the EMCS so that a remote SCU, UC, or OWS can connect up to the LAN and can function the same as if it were locally-installed.
- U. System Printer: a printing device which is installed on the LAN so that all EMCS components can utilize it as an output device.
- V. TCC: Temperature Controls Contractor - The entity responsible for the work described by this section of specifications.

1.3 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. Temperature Differential: Plus or minus 0.25 deg F.
 - f. Relative Humidity: Plus or minus 5 percent.
 - g. Airflow (Pressurized Spaces): Plus or minus 3 percent of reading.
 - h. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - i. Air Pressure (Space): Plus or minus 0.01-inch wg.

1.4 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.

1.5 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 +/- 1°F of 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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.

1.10 INSTRUCTION AND TRAINING

A. Interactive Operator HVAC Training System

1. General:

- a. Provide necessary software and learner workbooks to form a complete HVAC training system as described in this specification. Provide two (2) copies of the software and three (3) copies of the learner workbooks for the Owner's use.

2. Operation:

- a. Usable by multiple students while maintaining records and bookmarks for each learner.
- b. Operates from CD-ROM without the necessity of installing the program on a hard disk, or installed on hard drive. Students records stored on the computer's hard drive.

3. Features

- a. Integrates text and graphics to explain the concepts of building environments, the systems that deliver these environments, and the controls that manage these systems.
- b. Modular in design to allow the student to select and view whichever sections are appropriate in any order desired.
- c. Menu driven with complete sections identified on the menu.
- d. Includes a glossary of terms readily accessible from within the lessons allowing the review of a definition without losing the current lesson location.
- e. Incorporates navigational aids including a learning map that allows the student to move directly to a desired section from the map.

- f. Includes a password protected registration system to record student responses and bookmark progress. The registration system shall allow students to return to their previous lesson location or start the lesson again when logging on after the first session.
- g. Includes a password protected mentor mode which can be used to monitor progress throughout the training program.
- h. Includes mastery exam for each of the three sections of the training program; environments, systems, and controls.
- i. Includes a final test, enabled by the mentor, to assure satisfactory completion of the learning program.
- j. Includes a completion form upon successful completion of the training experience.

B. 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. 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.

C. Include in closeout documentation signed letter of acknowledgment of receipt of factory authorized training, videotapes, and maintenance manuals.

1.11 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 supply of conditioned electrical branch circuits for control units and operator workstation.
- C. Coordinate equipment with Division 26 Sections on Electrical Power Monitoring and Control to achieve compatibility of communication interfaces.
- D. Coordinate equipment with Division 26 Sections on Panelboards to achieve compatibility with starter coils and annunciation devices.

- E. Coordinate equipment with Division 26 Sections on Motor Controls to achieve compatibility with motor starters and annunciation devices.
- F. 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. Basis of Design Standardized Vendor (SV):
 - 1. Schneider Electric Controls as installed by Day Automation.
- B. 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. TAC/Andover Controls Corporation.
 - 2. Armstrong.
 - 3. Automated Logic Corporation.
 - 4. Functional Devices Inc.
 - 5. Honeywell International Inc.; Home & Building Control.
 - 6. Invensys Building Systems.
 - 7. Johnson Controls, Inc.; Controls Group.
 - 8. KMC Controls/Kreuter Manufacturing Company.
 - 9. McQuay International.
 - 10. Siemens Building Technologies, Inc.
 - 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. Standalone Control Units (SCU).
 5. Application Specific Unitary Controllers (UC).
 6. All controls power wiring 120 volts or less, all network and communication wiring, fiber optic cable, and other controls communication media.
 7. All EMCS communications devices.
 8. All related field devices including remote I/O cabinets, transformers and power supplies, relays, contactors, transducers, switches, cabling, and related electronic control equipment.
 9. All necessary software and custom programming, including graphics and reports.
 10. All necessary inputs, outputs, and devices required to meet the features and intent described herein including but not limited to:
 - a. Transducers.
 - b. Water flow switches and sensors.
 - c. Differential Pressure sensors.
 - d. Hydronic control valves.
 - e. Opposed blade (control) or parallel blade (shutoff), low leakage dampers.
 - f. Temperature, pressure, and humidity sensors and safety devices.
 - g. Electronic valve and damper actuators.
 11. All other equipment necessary for a complete, operational, EMCS.
- B. The design of the EMCS shall network OWSs, FCs, NCUs, SCUs, 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. Apple or equal.
 - 2. Dell or equal
 - 3. Gateway or equal.
 - 4. Hewlett Packard or equal.
 - 5. IBM or equal
- B. Central Server Computer:
 - 1. Dimensions to fit standard 2S-2U slots.
 - 2. Single 750w Hot Plug Power supply, complete with UPS.
 - 3. INTEL Core i7 3.8 GHz minimum, 8MB L2 cache microprocessor
 - 4. Minimum 32GB dual-channel DDR3 1600MHz SDRAM memory.
 - 5. Provide four (4) internal minimum 500 GB, 7200rpm SATA 3Bbps 3.5 Hot-Plug with 12 – Hot Swap hard disk drives, with average access time of less than 30 milliseconds for storage of primary system data base and operating parameter files.
 - 6. 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.
 - 7. Provide built-in ethernet networking capabilities (10/100Mbps) and wireless capability.
- C. Desktop Workstation Computer:
 - 1. INTEL Core i7 3.8 GHz minimum, 8MB L2 cache microprocessor.
 - 2. Minimum 32GB dual-channel DDR3 1600MHz SDRAM memory.
 - 3. The CPU shall be for desktop use and shall have at least three (3) unused expansion slots.

4. Provide an Integrated AC'97 Full-Duplex Audio card.
5. Provide a 13 in 1 media reader.
6. Provide an on board Combo Drive: 40x/10x/24x CD-RW and 8x DVD-ROM.
7. Provide two (2) internal minimum 500 GB each, 7200rpm or solid state hard disk drives, with average access time of less than 30 milliseconds.
8. 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.
9. Provide built-in ethernet networking capabilities (10/100Mbps) and wireless capability.
10. Provide graphics controller similar to 4GB NVIDIA® GeForce® GTX 745 DDR3.
11. Accessories:
 - a. Provide a 24" flat panel monitor, backlit LCD, TFT, Midnight Gray, Up to 1920x1080 Pixels, 0.27 mm Pixel Pitch, Anti-glare with Hard Coating, 15-Pin D-Sub / 24-Pin DVI-D / S-Video / Composite Video / USB 2.0 Connectors.
 - b. Provide a black and white laser printer with parallel interface, twelve pages per minute minimum at 1200 dpi equivalent, ½ ream paper storage minimum, dual side printing.
 - c. Provide a 101-key enhanced style keyboard capable of generating all the standard ASCII characters. Function keys "F1" through "F12" and numeric keyboard shall also be a part of keyboard.
 - d. Provide stereo speakers.
 - e. Provide an optical mouse, two buttons and wheel, to serve as the pointing device.
 - 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.

D. Operator Workstation 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 (°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 Internet Explorer or Netscape Navigator. 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. Peak Demand Limiting
 - i. Free Cooling
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 STANDALONE CONTROL UNIT (SCU) PANEL

- A. SCUs shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors designed to integrate multiple Unitary Controllers, provide central processing capacity and integration of distributed processing, and interface directly with the system OWS and LAN.

- B. Each SCU panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification.
- C. The basic elements of the direct digital control system structure shall consist of standard components kept in inventory by the equipment supplier. The components shall not require customizing other than setting jumpers and switches, adding firmware modules or software programming to perform required functions.
- D. The system shall be capable of being expanded to its full capacity by adding sensors and entering programs in available random access memory (RAM). Future expansion shall not require hardware modifications to the controller.
- E. SCU shall be listed in accordance with UL 864 as required to provide direct control of all smoke dampers.
- F. Memory: Provide with sufficient memory to meet system performance requirements and support its own operating system, database system, and database including:
 - 1. Control processes
 - 2. Energy management applications
 - 3. Alarm management
 - 4. Historical/trend data for all points
 - 5. Maintenance support applications
 - 6. Custom processors
 - 7. Operator I/O
 - 8. Dial-up communications
 - 9. Manual override monitoring
- G. Point Types: Support the following types of point inputs and outputs:
 - 1. Digital inputs for status/alarm contacts
 - 2. Digital output for on/off requirement control
 - 3. Analog inputs for temperature, pressure, humidity, flow and position measurements.
 - 4. Analog outputs for valve and damper position control, and capacity control of primary equipment.
 - 5. Pulse inputs of pulsed contact monitoring.
- H. Expandability:
 - 1. The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators.
 - 2. The system architecture shall support expansion capacity of all type of SCU panels, and all point types included in the initial installation.

- I. Serial Communication Ports: Provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable Operator's Terminals. SCU panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.
- J. Hardware Override Switches:
 - 1. Provide the ability to manually override automatically executed commands at the SCUs via local, point discrete, onboard hand/off/auto operator override control via local keypad function for binary control points and with modulating control for analog control type points.
- K. Hardware Override Monitoring:
 - 1. SCU panel shall monitor the status or position of all override, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. EMCS panel shall also collect override activity information for daily and monthly reports.
- L. Local Status Indicator Lamps:
 - 1. The SCU panel shall provide local status indication for each binary input and output for content, up-to-date verification of all point conditions without the need for an operator I/O device.
- M. Integrated On-Line Diagnostics:
 - 1. Each SCU panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The SCU panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each SCU panel, and shall not require the connection of an operator I/O device.
- N. Sure and Transient Protection:
 - 1. Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transient consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all single wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.
- O. Power failure:
 - 1. In the event of the loss of normal power, there shall be an orderly shutdown of all SCU panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
 - 2. Upon restoration of normal power, the SCU panel shall automatically resume full operation without manual intervention.

- P. No digital control panel shall be loaded to more than 80% of its total available point capacity of the digital/analog/input/output sections.
- Q. The SCU shall perform its assigned control and energy management functions as a stand-alone unit. Stand-alone control shall include, but not be limited to:
1. Supply and/or water reset.
 2. Adaptive optimal start.
 3. Time of day start/stop.
 4. Zero energy band.
 5. Night purge/warm-up.
 6. Duty cycle.
 7. Control valve, damper, motor and alarm capabilities.
- R. EMCS Shall Operate Within The Following Limits:
1. Temperature 32°F to 120°F.
 2. Humidity 0 to 95% RH.
 3. Voltage +/- 10%.
- S. Control algorithms shall be available and resident in the EMCS to permit proportional, integral, derivative, incremental, floating and two position control modes in combination to meet the need of the application and to adapt to job conditions.
- T. Control shall be performed in a digital manner using the digital signal from the microprocessor based controller converted through electronic circuitry for modulation of electric or pneumatic actuators. This may take the form of a pulse width modulated signal or a true analog signal generated through a D/A convertor. Electro-pneumatic transducers used for pneumatic outputs shall be cabinet mounted either within the controller or in separate cabinet located immediately next to the digital control panel.
- U. Adjustments of control variables shall be available at the controller with the modem through a non-intelligent terminal. Hand held or mounted in cabinet face. If hand held devices are provided two shall be furnished. These adjustments shall include, but not be limited to, setpoints, proportional gain, integral rates, the velocity and acceleration constants associated with incremental control and on/off values of two-position control.
- V. The controller shall contain necessary mathematic, logic, utility functions, all standard energy calculations and control functions in ROM. These should be available in combination for programming the unit. These routines shall include, but not be limited to:
1. Math routines:
 - a. Basic arithmetic.
 - b. Binary logic.
 - c. Relational logic.
 - d. Fixed formulas for psychrometry.
 - e. Calculations.

2. Utility routines for:
 - a. Process entry and exit.
 - b. Keyboard functions.
 - c. Variable adjustments and output.
 - d. Alarm indication.
 - e. Restart.
 3. Control routines for:
 - a. Signal compensation.
 - b. Loop control.
 - c. Energy conservation.
 - d. Timed programming.
- W. Final field programs shall be stored in battery backed up RAM. The EMCS (SCUs, UCs, etc.) shall be supplied with a minimum of eight hours of battery backup for the RAM with an automatic battery charger.
- X. The EMCS shall be expandable by adding additional SCUs, UCs, etc., that operate through the processor of the EMCS.
- Y. Provide digital sensors, differential air and/or water flow switches, space temperature sensors (30°F to 90°F), outside and air temperature sensors (-30°F to 120°F), hot water temperature sensor (0°F to 300°F), chilled water sensors (30°F to 90°F), humidity sensors, static pressure sensors, and other sensors and switches required to perform functions as specified.
- Z. Provide transducers, EP switches, devices, required by the EMCS to position the control elements.
- AA. Provide electric and pneumatic interface devices.
- BB. The EMCS software shall contain a self-test procedure for checking the annunciator lights on the digital display, and the computer.
- CC. Variable shall be identified as being reliable or unreliable. When a calculation is required to use a value (sensed or calculated), which is identified as being unreliable, the unreliable data value will flash. The calculation will use a default value programmed into the unit.
- DD. Alarms (e.g., a pump that did not start) and deviation alarms (e.g., temperature out of limits) will be annunciated.
- EE. The SCUs, UCs, shall be enclosed in a metal cabinet. The cabinet shall be constructed such that it can be mounted and electrical terminations made during the construction phase of the project.
- FF. The EMCS cabinet shall be a hinged metal type with a baked enamel finish and provided with a key lock. Cabinets on each installation shall utilize one master key. Control wiring and system communications shall be electrically terminated inside the EMCS on a suitable termination board.

2.6 CONTROL UNITS

- A. Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
- B. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
- C. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - 1. Global communications.
 - 2. Discrete/digital, analog, and pulse I/O.
 - 3. Monitoring, controlling, or addressing data points.
 - 4. Software applications, scheduling, and alarm processing.
 - 5. Testing and developing control algorithms without disrupting field hardware and controlled environment.
- D. Standard Application Programs:
 - 1. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
 - 2. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
 - 3. Programming Application Features: Include trend points; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
 - 4. Remote communications.
 - 5. Maintenance management.
 - 6. Units of Measure: Inch-pound and SI (metric).
- E. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
- F. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

2.7 LOCAL CONTROL UNITS

- A. Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
- B. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

- C. Stand-alone mode control functions operate regardless of network status. Functions include the following.
 - 1. Global communications.
 - 2. Discrete/digital, analog, and pulse I/O.
 - 3. Monitoring, controlling, or addressing data points.
- D. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
- E. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

2.8 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.

2.9 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.

2.10 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.

2.11 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. Temperature Sensors:

1. Temperature sensors shall be:
- a. Platinum wound RTD Type $\pm 1^\circ\text{F}$. Factory calibration point - 70°F at 1000 OHMS or 0°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°F over a range of -40° to 240°F,
 - 2) Noncalibrated devices, accuracy traceable to NBS testing,
 - 3) Guaranteed stability of 0.2°F over a 15 year period,
 - 4) Interchangeable 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.

D. 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.

2.12 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. Where damper is separating outside air from the conditioned space with no intervening air handler, for example relief air and exhaust fan dampers with short connected duct runs only, and additionally where called for on the drawings with the designation “AAD,” provide automatic dampers of thermally broken insulated construction design as described herein.
3. 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.
4. Materials:
 - a. General-service dampers not covered by the below restrictions, in galvanized steel ductwork, may be of galvanized steel construction.
 - b. Dampers in aluminum ductwork: aluminum or stainless steel.
 - c. Dampers subject to corrosive fumes: stainless steel of a type resistant to the fumes.
5. 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.
6. 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.
7. 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.
8. 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. Globe valves - modulating service.

2. Valve Bodies:

- a. Screwed bronze bodies (2" size and smaller).
- b. 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.
- c. 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.
- d. Two or three way as required.
- e. Designed for 125 psi operating pressure.
- f. 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 "O 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 valve actuators shall be direct-coupled over the valve shaft, installed without connecting linkage.
- 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.

2.13 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. Surge Suppression (Sp) Receptacle:
 - 1. Surge suppression receptacle with metal oxide varister to dissipate the electrical energy of voltage spikes.
 - 2. 20 ampere, duplex, NEMA 5-20R configuration.
 - 3. Back and side wiring, high impact nylon body.
 - 4. May be integral to panels.

2.14 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 to 120 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 to 120 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 warranty 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.
- 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 labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Components."
- E. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."
- F. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant 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. 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.

- C. 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.
- D. 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.
- E. 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).
- F. 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.
- G. Safety Devices:
1. Manual Reset Low Limit: Install on all equipment handling both water and any percentage of unheated outside air, including equipment in boiler rooms handling combustion air, serpentine 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.
- H. Miscellaneous Devices: As required; install per manufacturer's written instructions.

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 the following:
 - 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 SCU PANEL LOCAL OR PORTABLE OPERATOR'S TERMINALS

- A. Each EMCS panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications.
 1. There shall be a provision for both permanently mounting the standalone EMCS panel operator terminal, or using it as a portable hand held unit.
 2. The EMCS panel operator terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single screen dynamic displays depicting entire mechanical systems.
 3. The operator functions provided by the EMCS panel operator terminal shall include, but not be limited to, the following:
 - a. Start and stop points
 - b. Modify setpoints
 - c. Modify PID loop setpoints
 - d. Override PID control
 - e. Change time/date
 - f. Add/modify start/stop weekly scheduling
 - g. Add/modify setpoint weekly scheduling
 - h. Enter temporary override schedules
 - i. Define holiday schedules

- j. View analog limits
 - k. Enter/modify analog warning limits
 - l. Enter/modify analog alarm limits
 - m. Enter/modify analog differentials
 - n. Viewpoint history files
4. The EMCS panel operator terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points" but shall provide totally open exchange of data between the operator terminal and any EMCS panel in the network.
 5. Operator access at all EMCS panel operator terminals shall be identical to each other, as well as identical to the PC or Laptop operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.
 6. The EMCS operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats of point named. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.
 7. A multifunction touch pad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the EMCS panel operator terminal shall change the limit touch pad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touch pad functions.
 8. Context Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "Help" function shall provide general system operating instructions and specific descriptions of commands available in the currently displayed menus.
 9. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the EMCS panel operator's terminal to eliminate cross reference or look up tables.
 10. In addition to instantaneous summaries, the EMCS panel operator's terminal shall allow a user to view a point history file for system points. Point history files shall provide a record of value of analog points over the last 24 hours, at 30 minute intervals, or a record of the last ten status changes for binary type points.

3.8 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. Heating Hot Water System with heat injection systems, primary hot water system, secondary hot water systems, 3-ways, 2-ways, etc.
 - c. Air Handling Units, air and water sides, with coil pumps, zones, etc.
 - d. 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. 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. Do not permit unrelated HVAC equipment (heating valves, pumps, etc..) in building to lose control.
 - c. 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.

H. 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.

I. Maintenance Management: Continuously totalize run hours for equipment controlled and/or monitored for use by the maintenance management program.

J. 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.

K. Coil Freeze Protection.

1. Heating 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 60°F (adj.), the coil control valve shall be under space temperature control. If at any time the expected freeze location sensed temperature drops below 60°F (adj.), the control valve shall temporarily open to raise that coil's return water temperature to above 80°F (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 safety, above.

3.9 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 safety.
 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 pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 5. Check temperature instruments and material and length of sensing elements.
 6. Check control valves. Verify that they are in correct direction.

7. 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.

3.10 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.

3.11 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.

3.12 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 conditioning condensate drain piping.
 - 3. 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. Copper Hydronic Piping: 125psig at 250 deg F.
 - 2. PVC Hydronic Piping: 90psig at 110 deg F.
 - 3. CPVC Hydronic Piping: 90psig at 140 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. Pressure Control
 - 6. 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.

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. 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.

2.2 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441/F 441M, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.
- B. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
- C. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.
- D. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2665 for DWV fittings, ASTM D 2466 for Schedule 40 pipe fittings; ASTM D 2467 for Schedule 80 pipe fittings.

2.3 JOINING MATERIALS

- A. 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.
- B. 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.
- C. Solvent Cements for Joining Plastic Piping:
 - 1. CPVC Piping: ASTM F 493.
 - a. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), in contrasting color.

2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), in contrasting color.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. KBi.
2. CPVC and PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. KBi.
 - c. NIBCO INC.
2. MSS SP-107, CPVC and PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and metal threaded union.

2.5 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials, 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.

2.6 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".

2.7 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 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.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Closed Loop Hydronic Piping aboveground, NPS 2 and smaller:
 - 1. Type L drawn-temper copper tubing with wrought-copper fittings, and soldered or brazed joints.
- B. Air-Conditioning Condensate Gravity Drain Piping:
 - 1. Type M or L, drawn-temper copper tubing, wrought-copper drain fittings, and soldered joints.
 - 2. Schedule 40 PVC or CPVC plastic pipe, DWV style fittings, and solvent-welded joints.
- C. 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 eighth 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. 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.
 - b. Install out of the line of coil pull, tube bundle removal access space, etc.
 - c. Install so sensor wires, thermometers, gauges, etc., need not be rotated, removed, or disconnected to service equipment.
 - d. Install within two feet of control valves with no elbows between valve and union as required for ease of replacement.
 - e. 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. Plastic Piping Solvent-Welded Joints:

1. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
2. PVC Non-pressure Piping: Join according to ASTM D 2855.
3. Square cut and ream pipe ends to correct length.
4. Clean exterior of pipe and interior of fittings with rags and water and dry thoroughly before solvent cleaning with primer.
5. Check dry fit for interference fit to ensure pipe can be pushed at least 1/3 of way into fitting by hand. Ensure pipe that "bottoms" is snug.

6. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
7. Use only approved cement and primer suitable for types of pipes and fittings used and suitable for intended service, including temperature, pressure pipe size, and fluids served. Use only fresh cement; do not use thickened, lumpy, or "jelly like" cement.
8. Clean pipe and fitting with cement manufacturer's primer or cleaner. Use contrasting color primer and cement.
9. Stir or shake cement before use. Apply thin coat of cement in socket, then evenly coat pipe end to socket depth. Avoid puddling, especially on thin walled pipe.
10. Assemble joint by twisting pipe 1/4 turn while pushing to full socket depth. Provide adequate anchorage and leverage to assemble pipe to full socket depth of fittings; hand pressure is inadequate and not acceptable for larger sizes. Hold pressure for 30 seconds or as required avoiding push out. Allow additional time for cement to set in colder weather to ensure cement film cures without blisters. Wipe off excess cement between socket and pipe with clean, dry rag.
11. Keep cement cool in hot weather and work as quickly as possible to avoid cement setting up before joint is assembled. Keep lid on cements, cleaner, and primers when not in use. Do not mix cleaner or primer with cement.
12. Use 3/4-inch dauber on small diameter pipes.

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 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 of 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.

- E. 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."
- F. 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.
- G. Install piping to pumps. Details of near pump piping are specified in Section 23 21 23 "Hydronic Pumps".

3.5 VALVE APPLICATIONS

- A. Install General Duty Valves (isolation 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 pumps for proper rotation.
3. 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).
4. Set temperature controls so all coils are calling for full flow.

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 as scheduled:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 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. VRF Manufacturer's recommended refrigerant tubing, fittings, valves, etc.
 - 3. Thermostatic expansion valves.
 - 4. Solenoid valves.
 - 5. Filter dryers.
 - 6. Strainers.
 - 7. Pressure-regulating valves.

- B. Shop Drawings: Show diagrammatic layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Refrigerant piping indicated on Drawings is schematic only. Coordinate with VRF manufacturer to size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

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 Specialties."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: 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 as indicated herein and as recommended by VRF manufacturer:

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. Check Valves as indicated herein and as recommended by VRF manufacturer:

1. Body: Forged brass or cast bronze; globe pattern.
2. Bonnet: Forged brass or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

C. Service Valves as indicated herein and as recommended by VRF manufacturer:

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.

D. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by an NRTL as indicated herein and as recommended by VRF manufacturer.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.

4. End Connections: Threaded.
 5. Electrical: Molded, watertight, replaceable AC coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and voltage as required.
 6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
 8. Include Manual operator.
- E. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL as indicated herein and as recommended by VRF manufacturer.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat Disc: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Working Pressure Rating: 400 psig.
 6. Maximum Operating Temperature: 240 deg F.
- F. Thermostatic Expansion Valves: Comply with AHRI 750 as indicated herein and as recommended by VRF manufacturer.
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.
- G. Straight-Type Strainers as indicated herein and as recommended by VRF manufacturer:
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.
- H. Angle-Type Strainers as indicated herein and as recommended by VRF manufacturer:
1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.
 5. Working Pressure Rating: 500 psig.
 6. Maximum Operating Temperature: 275 deg F.

- I. Moisture/Liquid Indicators as indicated herein and as recommended by VRF manufacturer:
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.
- J. Replaceable-Core Filter Dryers: Comply with AHRI 730, and as indicated herein and as recommended by VRF manufacturer:
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: as recommended by VRF manufacturer.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow: Refer to drawing schedules and manufacturer's data.
 9. Working Pressure Rating: 500 psig.
 10. Maximum Operating Temperature: 240 deg F.
- K. Permanent Filter Dryers: Comply with AHRI 730, and as indicated herein and as recommended by VRF manufacturer:
1. Body and Cover: Painted-steel shell
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: as recommended by VRF manufacturer.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow: Refer to drawing schedules and manufacturer's data.
 9. Working Pressure Rating: 500 psig.
- L. Mufflers as indicated herein and as recommended by VRF manufacturer::
1. Body: Welded steel with corrosion-resistant coating.
 2. End Connections: Socket or flare.
 3. Working Pressure Rating: 500 psig.
 4. Maximum Operating Temperature: 275 deg F.

M. Receivers: Comply with AHRI 495, and as indicated herein and as recommended by VRF manufacturer:

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

N. Liquid Accumulators: Comply with AHRI 495 and as indicated herein and as recommended by VRF manufacturer:

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, R454B.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R454B

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.

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. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. 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.
- F. 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.
- G. 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. Hot-gas bypass valves.
 - 3. Compressor.
- H. 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.
- I. Install receivers sized to accommodate pump-down charge.
- J. 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. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground. Provide for drainage and liquid accumulation.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. 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.
- O. 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.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Components."
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23.
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23.
- T. 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 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.

3.6 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.

3.7 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 controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Verify that compressor oil level is correct.
 - 2. Open compressor suction and discharge valves.
 - 3. Open refrigerant valves except bypass valves that are used for other purposes.
 - 4. 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 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. Fabricate ductwork able to withstand the forces imposed by the support and restraint system. Refer to Specification Section 23 05 48 "Mechanical Wind Load Control" for additional information and requirements.

- D. Provide all duct systems continuously electrically bonded to ground.

1.5 SUBMITTALS

- A. Comply with requirements of SECTION 01 33 00 "Submittal Procedures" 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 "Submittal Procedures" 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.

E. Coordination Drawings:

1. Prepare 1/4" = 1' scale or larger drawings for all areas requiring coordination drawings 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 “Submittal Procedures” 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) Soffits.
 - 7) Perimeter moldings.
2. Submit Coordination Drawings to Construction Manager, and each affected Prime Contractor for review and coordination in accordance with the schedule agreed upon during the coordination meetings.

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 Conference of Governmental Industrial Hygienists
 - a. "Industrial Ventilation – A Manual of Recommended Practice for Design", for contaminant control and industrial ventilation design
 - 3. American Society of Civil Engineers (ASCE):
 - a. ASCE7 Minimum Design Loads for Buildings and Other Structures
 - 4. 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
 - 5. 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.
 - c. AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
 - 6. 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
7. National Air Duct Cleaners Association (NADCA):
- a. ACR “Assessment, Cleaning and Restoration of HVAC Systems”, for duct cleanliness standards.
8. National Fire Protection Association (NFPA):
- a. 90A Standard for the Installation of Air Conditioning and Ventilating Systems
 - b. 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
9. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
- a. HVAC Duct Construction Standards, Metal and Flexible
 - b. HVAC Air Duct Leakage Test Manual
10. Underwriters Laboratories, Inc. (UL):
- a. 181 Factory Made Air Ducts and Air Connectors
 - b. 555 Standard for Fire Dampers
 - c. 555S Standard for Smoke Dampers

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.
- E. Kitchen supply and exhaust duct service, dishwasher exhaust service: ASTM A 480/A 480M, Type 304L or 316L Stainless-Steel Sheets; cold rolled, annealed. Minimum surface finish for concealed duct No. 2B exterior of duct, No. 2D interior of duct.
- F. 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).
 - 2. Flexible Duct (Ambient Temperature abuse resistant applications similar to wood dust exhaust systems): Minimum factory temperature rating of 200 deg. F., constructed with two ply, triple overlap, fully EPDM impregnated woven abrasion resistant, fire retardant fabric with an enclosed spring steel wire, and extra abrasion resistant strip covering wire. Factory attached fittings. Type "NE" by Car-Mon Products (design make).
- G. 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. 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.
4. Single Wall Turning Vanes
- a. Provide in mitered rectangular elbows of increasing or decreasing cross section and those with a turning angle greater than 100 degrees or less than 80 degrees.
 - b. Blades of single wall 16 gauge construction with leading and trailing edges aligned to the direction of flow, installed per SMACNA Duct Manual standards so as to provide smooth area transition. Maximum spacing 3 inch, unless otherwise approved.

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.
- 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. Offsets:

1. All offsets to consist of paired curved elbows, each of the required angle, combined into one fitting.

G. 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 TYPE I AND TYPE II KITCHEN HOOD EXHAUST DUCTS:

- A. Type I and Type II hood service duct: in compliance with NFPA 96, all related code requirements, and the additional requirements of this section.
- B. Material: 18 gage minimum stainless steel, number 4 polish for duct exposed to view in finished space.
- C. Construction:
 1. Fabricate duct from minimum 18 gauge externally continuously TIG welded stainless steel, not cross-broken.
 2. Grind and polish all welds to match #4 finish and remove all weld heat discoloration. Distortion from overheating or forcing is unacceptable.

3. Smooth radius elbows with ratio of outer radius to inner radius no greater than 2, smooth transitions with no steps, no mechanical fasteners extending into airstream, eliminate all eddies and other locations where grease or condensate will inadvertently accumulate.
 4. Prove liquid tight at all welds, seams, and joints.
- D. Slope duct continuously per code and NFPA, minimum one quarter inch per foot (1:48 or 2% slope) up to 75 feet horizontal, or above 75 feet horizontal at one inch per foot (1:12 or 8.3% slope) preferably back to the equipment, or to a grease reservoir.
1. Where ducts are not self-draining to equipment provide low point grease reservoir / drain pockets at all duct low points:
 - a. Full width of duct, welded construction, twelve inches (12") long in direction of airflow and one inch (1") deep minimum, bottom sloped deeper towards drain for positive drainage with welded on stainless steel drain pipe nipple with $\frac{3}{4}$ " NPT threaded connection point outside of insulation.
 - b. Type I service connection: valve and capped hose thread for periodic grease collection
 - c. Type II service connection: trapped as required for system pressure and connected to condensate drain pipe as specified, extended to sanitary sewer through grease trap.
- E. Verify size of hood and fan duct connections in field, provide duct to fit equipment connections with smooth transitions to duct size indicated or if not indicated on drawings to next full inch size smaller than that which would have velocity of 1500 fpm at given cfm. Configure duct so that duct velocity is not less than 500 fpm at any point in the duct.
- F. Provide access doors or panels for duct cleaning on horizontal duct at grease reservoir / drain pockets, at 12 foot intervals, and at each change of direction. Access doors or panels shall be of the same material and thickness of the duct with reinforced flanges, flush interior surfaces, water and grease-tight high temperature gaskets and sealants, and easily reusable fire rated insulation covers.
1. Type I access door assemblies complete, rated for 1500 degrees F service.
- G. Where clearance to other construction permits, double-wall insulated factory-built grease duct and accessories, inner and outer walls 300 series stainless steel, UL labeled and complying with NFPA 96 may be used in lieu of specified materials, with installation in compliance with the manufacturers' requirements. Convert any square and rectangular duct shown on the drawings to round size of equal or greater hydraulic radius with custom transitions meeting all the requirements of this specification.

2.6 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. 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".

C. 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, 1/2" 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) Same material as ductwork, 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.

D. Duct Access Control:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following. Note not all manufacturers offer all products:
 - a. American Warming and Ventilating; a division of Mestek, Inc.
 - b. Carnes.
 - c. Cesco Products; a division of Mestek, Inc.
 - d. Ductmate Industries, Inc.

- e. Flame Gard, Inc.
 - f. Flexmaster U.S.A., Inc.
 - g. Greenheck Fan Corporation.
 - h. KEES, Inc.
 - i. Lloyd Industries, Inc.
 - j. Metal Form Manufacturing, Inc.
 - k. McGill AirFlow LLC.
 - l. 3M
 - m. Nailor Industries Inc.
 - n. Price Industries.
 - o. Ventfabrics, Inc.
 - p. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
2. General Purpose Duct-Mounted Service Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
- a. Door:
 - 1) Double wall, rectangular.
 - 2) Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - 3) Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - 4) Fabricate doors airtight and suitable for duct pressure class.
 - b. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - c. Number of Hinges and Locks:
 - 1) Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - 2) Access Doors up to 18 Inches Square: Two hinges and two sash locks.
3. Grease Duct or Type I Cooking Hood Exhaust Duct Access Door:
- a. UL 1978 listed, meets NFPA 96 standards.
 - b. Twin layer 11 gauge (0.120-inch) panels, same steel as duct.
 - c. Minimal protrusion into duct, no more than inner door thickness.
 - d. Inner panel with profiled access opening welded to duct interior, with welded on studs.
 - e. Outer door hinged to duct with full coverage ceramic gasket rated for 2300 deg F.
 - f. Hinge welded to duct, screwed to outer completely removable for cleaning panel.
 - g. Tool free access: perimeter studs with wing nuts.
 - h. Center handle folds flat under insulation.
 - i. Provide with extension bolts/coupling nuts or extended studs and UL listed reusable insulation cover and plate.

4. Grease Duct or Type I Cooking Hood Exhaust Duct Access Panel:
 - a. UL 1978 listed, meets NFPA 96 standards.
 - b. Twin layer 11 gauge (0.120-inch) panels, same steel as duct.
 - c. Minimal protrusion into duct, no more than inner door thickness.
 - d. Ceramic board gasket rated for 2300 deg F covers entire outer door.
 - e. Tool free access with center and perimeter studs with wing nuts.
 - f. Easily removable for cleaning.
 - g. Center handle folds flat under insulation.
 - h. Provide with extended studs and UL listed reusable insulation cover and plate.
5. Instrument Test Access Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

2.7 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 11. 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."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. 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."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. 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.

2.8 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. Where ducts pass through fire-rated interior partitions and exterior walls, install fire or combination fire-smoke dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- Q. Where duct passes through exterior walls and roofs from interior to exterior, provide water and airtight penetration detailing as required, preserving the thermal, moisture, and vapor penetration resistance of the surrounding assembly.
- R. 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 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped up from hood to outlet or down from high point to a grease reservoir as specified, a minimum of 1:48 (2 percent) for horizontal runs up to 75 feet and 1:12 (8.3percent) for runs above 75 feet. Where continuous slope up is not possible,
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.6 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 A - Greater than 2 inch w.g. and for air and water tight ductwork described below.
 - 2. Seal Class B – 2 inch w.g. and less general supply, return, and exhaust ductwork.

3.7 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".
 - 4. Section 23 05 48 "Mechanical Wind Load 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.

3.8 CONNECTIONS

- A. Make connections at all intake and discharge connections between duct and vibration producing equipment with fans 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.

3.9 FIELD QUALITY CONTROL

A. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
 - a. All duct specified as water tight including but not limited to all exterior duct and all type 1 and type 2 kitchen hood exhaust duct.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.

5. Prior to the use or concealment of any portion of a grease duct system including all Type 1 and Type 2 kitchen hood exhaust systems provided or modified in this project, perform a Grease Duct Leakage Test. Concealment includes installation of shaft walls, hard ceilings, and other fixed architectural elements around duct as well as covered by insulation, coatings, or wraps that prevent the ductwork from being visually inspected on all sides. Provide all labor and equipment required to perform a light test to determine that all joints are liquid tight.
 - a. Grease Duct Leakage Test: pass a lamp having a light output rating of not less than 1500 lumens total nor less than 1000 lumens per foot through the entire section of ductwork to be tested. Provide an open lamp that emits light equally in all directions radially from the nominal duct centerline. Darken space duct is installed in to increase visibility of any leaked light, and visually inspect entire circumference of duct for leaked light, section by section, paying special attention to joints and weld pin locations. Between sections, move point source lights similar in size to an incandescent light bulb no more than three feet, and move linear lights similar to fluorescent tubes no more than the bulb length plus two feet. Mark any leak locations on duct, repair after test, and re-perform light test until no light leaks remain. Perform test for the entire duct system affected by the project, including the hood-to-duct connection and all points through the fan to the exterior. Test the ductwork in sections, provided that every joint provided or modified by this project is tested. For listed factory-built grease ducts, testing may be limited to duct joints assembled in the field, excluding factory welds.
 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 7. Give seven days' advance notice for testing.
- 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 and existing duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. 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.
- D. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 4. Provide drainage and cleanup for wash-down procedures.

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 33 00 - DUCTWORK ACCESSORIES

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. Fire Dampers, Smoke Dampers, and Combination Fire and Smoke Dampers.
 - 2. Auxiliary Condensate Control.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide Ductwork Accessories in compliance with all applicable requirements of Section 23 31 00 "Ductwork" and appropriate design and construction manuals issued by Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
- B. Fire, Smoke and Fire/Smoke Dampers: Provide dampers listed for the application in locations shown on Drawings or specified in this Section including all new ducts penetrating fire rated general construction and in accordance with NFPA 90A maintaining the fire rated integrity of the general construction.
- C. Auxiliary Condensate Control: Provide as required to protect building components from condensate overflow where manufacturers' condensate control system does not provide for auxiliary protection.

1.4 ACTION SUBMITTALS

- A. Product Data: For all Ductwork Accessories, as required demonstrating compliance with specified requirements.
- B. Shop Drawings: For all Ductwork Accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail Ductwork Accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Additionally include the following as required for specific applications:
 - a. Fire-damper, smoke-damper, combination fire- and smoke-damper installations: include sleeves, duct-mounted access door locations, and motorized damper operators.

- b. Exhaust Hoods: include sub-frame mounting requirements and adjustment mechanisms.
 - c. Machinery Safety Guards: include detailed operating and service clearance dimensions.
 - d. Auxiliary Condensate Control: include dimensions of equipment served, clearance to general construction, and service access.
2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Ductwork Shop and Coordination Drawings: Include Ductwork Accessories in Ductwork Shop Drawings and Ductwork Coordination Drawings, only after approval of ductwork accessories submittals detailed in this section. Refer to Section 23 31 00 "Ductwork" for details.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Comply with all applicable codes and as follows.
- B. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Fire, Smoke, and Combination Fire – Smoke Dampers: Rated, listed, and labeled according to UL 555 and UL 555S by an NRTL.
- D. Kitchen Hood Service: Comply with NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations" and UL 710 "Standard for Safety Exhaust Hoods for Commercial Cooking Equipment".
- E. Comply with AMCA 500-D testing for damper rating.

1.8 EXTRA MATERIALS

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

- 1. Fusible Links: Furnish the larger of 10 percent of amount installed, or minimum 3.

PART 2 - PRODUCTS

2.1 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. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M, G90 coating designation, lock forming quality, unless otherwise specified..

1. Exposed to view, not externally insulated or painted: Galvannealed steel.
2. Exposed to view, to be painted: Galvannealed steel prepared for painting via mill phosphatizing and subsequent heat treatment in accordance with ASTM D6386 and ASTM D7803 as applicable

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304L or 316L Stainless-Steel Sheets; cold rolled, annealed. Minimum surface finish for concealed duct No. 2B exterior of duct, No. 2D interior of duct. Minimum surface finish for duct exposed to view in occupied spaces, No. 4 polish.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

2.2 CONTROL DAMPERS

A. Refer to Section 23 09 00 "Instrumentation and Control for HVAC" for control damper specifications.

2.3 FIRE 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. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Metal-Fab Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Prefco; Perfect Air Control, Inc.
9. Ruskin Company.

10. Vent Products Company, Inc.
 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Provide curtain-blade or multi-blade dampers as required by size and application.
- C. Type: Dynamic rated and labeled according to UL 555 and/or UL 555S by an NRTL.
1. Rated for ducts up to 4-inch wg static pressure class and 4000-fpm velocity.
 2. Mounting Orientation: Vertical or horizontal as required by application.
 3. Include blade lock and stainless-steel closure spring sufficient for Mounting Orientation.
- D. Fire Rating: 1-1/2 or 3 hours as required; refer to drawings for fire rating of general construction.
- E. Frame: Fabricated with roll-formed, 0.034-inch- thick galvanized or stainless steel; with mitered and interlocking corners. Provide frame Type "C" unless otherwise specified or shown on drawings and materials as specified and detailed in Part 3 - Execution.
1. Type "C": 100% free area curtain style with frame and retracted blades outside airstream.
 2. For dampers shown or required by general construction conflicts to be installed with damper blades outside of the plane of the fire resistive general construction, provide factory assembly UL listed for this installation including extended reinforced sleeve factory covered with fire rated insulation meeting or exceeding the rating of the surrounding general construction.
- F. Mounting Sleeve: Factory- or field-installed, same steel as frame.
1. Minimum Thickness: equal to the thicker of the attached duct material, 0.052 inches, or as required by product listing, and of length to suit the associated wall or floor construction.
 2. Provide with (4) 1-1/2 inch X 1-1/2 inch, 14 gauge galvanized steel mounting angles to be field attached to the sleeve only.
 3. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Blades: Roll-formed, interlocking, 0.034 inch thick sheet steel of same type as frame. In place of interlocking blades, use full-length steel blade connectors.
- H. Heat-Responsive Device: Replaceable fusible links rated for 165 deg F or other temperature where noted on drawings.
- 2.4 SMOKE DAMPERS AND COMBINATION FIRE AND SMOKE 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. Cesco Products; a division of Mestek, Inc.
 3. Greenheck Fan Corporation.

4. Nailor Industries Inc.
 5. Ruskin Company.
- B. Type: Listed and labeled according to UL 555 and UL 555S by an NRTL for pressure and velocity to exceed design airflow conditions for dynamic closure in ducts up to 4-inch wg. static pressure class and minimum 2000 fpm velocity.
 - C. Fire Rating of dampers designated as combination Fire-Smoke Dampers 1-1/2 hours as required; refer to drawings for fire rating of general construction:
 - D. Heat-Responsive Device of dampers designated as combination Fire-Smoke Dampers: Factory installed electric resettable link and switch package, rated for 165 deg F.
 - E. Corrosion resistance: Galvanized steel for use in galvanized steel ductwork, stainless steel for use in aluminum or stainless steel ductwork.
 - F. Frame: Multiple-blade type with frame outside of airstream; fabricated with roll-formed, 0.060-inch- thick steel; with mitered and interlocking corners.
 - G. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick steel blade connectors.
 - H. Leakage: Class I.
 - I. Mounting Sleeve: Factory-installed, 0.052-inch- thick sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
 1. For fire rated dampers shown or required by general construction conflicts to be installed with damper blades outside of the plane of the fire resistive general construction, provide factory assembly UL listed for this installation including extended reinforced sleeve factory covered with fire rated insulation meeting or exceeding the rating of the surrounding general construction.
 - J. Damper Actuator Motors:
 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 19 "Common Electrical Requirements for HVAC Components".
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 28 31 11 "Digital, Addressable Fire-Alarm and Mass Notification System".
 3. Coordinate electrical voltage, connections, and signaling characteristics with facility fire alarm system, typically 115 v, single phase, 60 Hz.
 4. Motor Sizes: As required for the UL listing.
 5. Provide with two-position action.

6. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed metal gear trains.
7. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running and breakaway torque rating of 150 in-lbf or as required by damper size and listing.

K. Accessories:

1. Auxiliary end switches for position indication.
2. Test and reset switches.
3. Integral smoke detector, factory wired and installed in duct sleeve.
4. Control panel integrating Smoke and Fire-Smoke Dampers for testing and monitoring use in smoke-management systems.

2.5 AUXILIARY CONDENSATE DRAIN SYSTEM

- A. Provide a secondary drain or auxiliary drain pan for each cooling or evaporator coil where damage to any building component will occur as a result of overflow from the equipment drain pan or stoppage in the condensate drain piping. Provide one of the following:
1. Provide an auxiliary drain pan with the following characteristics underneath coils where condensation will occur:
 - a. Galvanized steel, minimum depth 1-1/2 inches, not less than 3 inches larger each horizontal direction than the unit or coil dimension it serves. Pitch drain pan to direction of discharge; provide a separate overflow drain line to discharge at point indicated, or to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain.
 2. Provide a separate overflow drain line connected to the drain pan provided with the equipment. Discharge overflow drain at an approved conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. Connect the overflow drain line to the drain pan at a higher level than the primary drain connection.

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 duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories with stainless steel fire and fire-smoke dampers in aluminum ducts.
- C. Install fire and smoke dampers according to UL listing and in compliance with the latest edition of NFPA 90A.
 - 1. Provide for adequate perimeter clearance and fire rated flexible infill as required, in accordance with the manufacturers instructions and so as to not cause interference with the operation of the damper due to restricted thermal expansion.
 - 2. Provide Type C frame dampers, or, increase damper size in each dimension by an amount such that the free opening is the specified duct size minimum, and provide duct transitions on either side. Example: 12" x 20" duct with Type A 7/8 inch frame and nominal damper size 1/4 inch less than listed duct with blades protruding 3 inches into duct - use 17" x 20" Type A damper.
 - 3. For all fire and fire/smoke dampers installed in duct, plenum casing, or other building construction openings which must be fire rated, with nominal cross section dimensions in width or height greater than the manufacturer's maximum available dimensions, provide multiple dampers and all interceding support structure as required to fabricate a U.L. listed fire damper assembly of the required free area cross section.
 - 4. Provide access door(s) in duct and building construction where required for access for each damper in suitable locations to permit reasonable access to and resetting of the damper blades. Demonstrate access and resetting of thermal linkage during commissioning.
- D. Install Auxiliary Condensate Drain Systems where required. Adjust to be level / properly sloped under empty and fully loaded condition. Connect to properly piped gravity condensate drain piped to point of approved discharge.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate all dampers to verify full range of movement.
 - 2. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
 - 3. Demonstrate proper service access at all dampers.
 - 4. Inspect installation of all Auxiliary Condensate Drain Systems and demonstrate they perform their intended function

END OF SECTION 23 33 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.
 - 2. Ceiling-mounted ventilators.
 - 3. In-line centrifugal fans.

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.
- B. Review approved kitchen fan submittal as described in Div. 11 sections in preparation for the installation.

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. Roof curbs.
 - 7. 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. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension assembly members.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

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.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for commercial kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 ROOFTOP CENTRIFUGAL EXHAUST FANS

- A. Unit Description: UL listed exhaust fan specifically designed for outdoor installation and service, shipped fully assembled and factory tested prior to shipment.
1. Housing:
 - a. Spun 16 gauge minimum weather tight marine grade aluminum two piece upper housing, with reinforced rolled edges. Down-blast, or up-blast housing as scheduled.
 - 1) Fully welded aluminum curb cap
 - b. Rubber grommited internal wiring passages unless otherwise specified.
 - c. Provide aluminum nameplate riveted to housing exterior with manufacturer, model, cfm, static pressure, and electrical characteristics all permanently engraved or stamped.
 2. Impellers: Backward inclined, non-overloading, statically and dynamically balanced all aluminum construction, including hubs. Impeller shall overlap a spun aerodynamic inlet cone. Belt or direct drive as shown on Drawings.
 3. Power Assemblies:
 - a. Motor and drive isolated from discharge air stream in forced-air cooled compartment.
 - b. Power Assembly mounted on minimum 14 gauge plated steel structure, supported on housing with rubber isolators loaded in combination shear and compression.
 - c. Motors:
 - 1) Refer to section 23 05 13 "Common Electrical requirements for HVAC Components" for additional information.
 - 2) Constant Speed Operation: Open drip-proof type with sealed, permanently lubricated ball bearings; pre-wired through to disconnect switch mounted under fan cover with sufficient legs to break all leads to motor.
 - a) Motors, wiring, and disconnects serving fume hood exhaust fans and other potentially flammable exhaust streams shall be UL listed and in accordance with NEC for explosion proof construction.

4. Accessories / options as scheduled:

- a. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
- b. Bird Screen: Removable, 1/2-inch mesh, aluminum or brass wire.
- c. Manual Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

B. Manufacturers: Cook, Greenheck, Penn Ventilator, Twin Cities, or Approved Equal.

2.2 CEILING-MOUNTED 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. Breidert Air Products.
2. Carnes Company.
3. Greenheck Fan Corporation.
4. Loren Cook Company.
5. PennBarry.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: High-impact styrene, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing.

F. Accessories:

1. Fan speed controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Rubber in shear mounting bracket.
3. Disconnect switch.
4. Integral back draft damper.

2.3 IN-LINE CENTRIFUGAL FANS

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. PennBarry.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
 - C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
 - D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
 - E. Accessories:
 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 3. Companion Flanges: For inlet and outlet duct connections.
 4. Vibration Isolators: Elastomeric

2.4 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.

2.5 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 kitchen hood exhaust fan furnished under Division 11.
- B. Install power ventilators level and plumb.
- C. Support units as described herein having a static deflection of 1 inch. Vibration-control devices are specified in Section 23 05 43 "Mechanical Vibration and Movement Control".
- D. Secure roof-mounted fans to roof curbs with stainless steel hardware. Anchor equipment to roof curb with fasteners located 12" on center with a minimum of two fasteners on each side.
- E. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- F. Support suspended units from structure using threaded steel rods and vibration hangers having a static deflection of 1 inch. Vibration-control devices are specified in Section 23 05 43 "Mechanical Vibration and Movement Control".
- G. Install units with clearances for service and maintenance.
- H. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

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. Verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke 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. 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
 - b. Roof Top hoods

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.
 - 2. Air Louvers: Provide AMCA-rated louvers for all fresh air intake and exhaust openings, except as otherwise shown or specified in Contract Documents. Cross- reference dimensions of each louver shown on heating drawings with those on the architectural drawings. Notify architect in writing of any discrepancies prior to submitting on louvers.
 - 3. Roof Top Hoods : Provide fresh air intake and exhaust / relief openings, as shown or specified in Contract Documents. Cross- reference dimensions of each hood shown on heating drawings with those on the architectural drawings. Notify architect in writing of any discrepancies prior to submitting on equipment.

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.

- B. Exterior Outlets and Inlets Delegated Design: Include comprehensive engineering analysis by a qualified professional engineer, using wind, snow, gravity, and seismic loading criteria as indicated on the code compliance drawings. Factory standard certifications are acceptable for factory standard products; custom certification is required for custom products.
 - 1. Components shall withstand the effects of the specified loads within limits and under conditions indicated without permanent deformation, noise or metal fatigue caused by vibrations or permanent damage to fasteners and anchors.
 - 2. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
 - 3. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.5 SUBMITTALS

- A. Comply with requirements of SECTION 01 33 00 "Submittal Procedures" 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, Louvers, and roof Top Hoods.
 - 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, and Roof Top Hoods: Include complete tabulated schedule showing locations for each Louver, and Roof Top Hood showing type, size, wall and/or roof 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.

1.6 SEQUENCING AND SCHEDULING

- A. Deliver Exterior Outlets and Inlets to project in sufficient time for installation in walls as wall construction progresses.
 - 1. Coordinate unit selection to meet requirements of other equipment and installation details (automatic dampers, back draft dampers, etc.).
 - 2. Verify all opening sizes, locations and mounting arrangements prior to installation.

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. Registers:

- 1. TYPE "R-B": Double deflection wall supply register; vertical front and horizontal rear vanes with 3/4" spacing between blades, rubber gasket to prevent streaking, vanes individually adjustable; steel construction. Similar to Krueger "880V" or "880H (horizontal front)".

C. Grilles

- 1. TYPE "G-A": Eggcrate return grille; 1/2 inch x 1/2 inch x 1 inch 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 Krueger "EGC-15".

D. Supply Diffusers:

1. TYPE "D-A": Architectural round plaque ceiling diffusers, of the sizes and mounting types shown on the plans. Round outer cone shall be constructed of 18-gauge steel and heavy gauge aluminum plaque face. The exposed surface of the plaque shall be smooth and flat. The airflow discharge pattern shall be field adjusted from horizontal to vertical by repositioning the plaque assembly using the adjusting screws. The plaque assembly shall be constructed as a single inner assembly and must be easily removable using a spring lock mechanism. Provide with retainer cable. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. Design basis: Titus R-Omni or Engineer approved equal.

E. AIR LOUVERS

1. Exhaust Louvers (Fixed Type)
 - a. Minimum 39% free area.
 - b. 4" deep standard frame
 - c. Continuous weepage at bottom, high rear water stop.
 - d. Extruded aluminum construction.
 - e. Clear anodized.
 - f. Design Basis: Ruskin BV100 or Engineer approved equal.

2.2 ROOF TOP HOODS

A. Dome Style Roof Top Hoods:

1. Rated for snow and wind load shown on Code Compliance Drawings.
2. Designed for intake or exhaust (relief), as shown on the drawings.
 - a. Intake hoods shall have minimum free area at inlet equal to twice the throat cross section.
 - b. Exhaust hoods shall have minimum free area at outlet equal to the throat cross section.
 - c. Provide closed cell insulation adhered to underside of exhaust /relief hoods to prevent condensation.
3. Heavy gauge (0.060 inch) aluminum construction.
4. All vertical seams continuously welded. Tops stressed and sloped for drainage with standing lock-formed seams; slope by cross breaking only of flat top not acceptable. All mechanical fasteners stainless steel.
5. Provide hinged joint between hood and base for ease of service access.
6. Provide 1/2 inch aluminum bird screen, secured in removable frame to underside of opening.

7. Curb: Install units on minimum 14" insulated curb or higher curb as scheduled; factory fabricated similar to Pate "Model PC-5A".
8. Size and capacity as shown on the drawings.
 - a. Provide scheduled factory finish as detailed below:
 - 1) Standard mill finish.
9. Provide products by one of the following:
 - a. Cook "G" series or equal.
 - b. Greenheck "Fabra Hood" or equal.
 - c. Twin City Fans and Blowers, "MG" series 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. 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.
 3. Provide suitable gaskets or coating where dissimilar metals are in contact.
 4. Clean aluminum surfaces promptly after installation of units. Remove excess glazing and sealant compounds, dirt, and other substances. Lubricate hardware and other moving parts.
- D. Roof-Mounted Hoods
1. Provide roof curbs in sufficient time to coordinate with construction schedule.
 2. Verify all opening sizes, locations, and mounting arrangements prior to installation. Provide structural support frame around all roof deck penetrations 12 inches x 12 inches and larger, unless specifically indicated otherwise elsewhere on the Contract Documents..
 3. Comply with applicable requirements of SECTION 23 05 29 "Hangers and Supports for HVAC Components".
 4. Comply with manufacturer's requirements for securing to curbs. Use appropriate weather proof gasketing and stainless steel fasteners as required meeting loading requirements specified above.

END OF SECTION 23 37 00

SECTION 23 62 13 – UNITARY AIR CONDITIONING 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. Split System Air Conditioners with Remote Condensing Units.
- B. Products Furnished but not Installed Under this Section.
 - 1. Associated refrigerant piping and condensate drain piping.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements
 - 1. Cooling performance rated in accordance with AHRI Testing.
 - 2. Unit efficiencies meet scheduled performance and exceed Energy Code Requirements.
 - 3. Units listed and labeled by UL and ETL.
 - 4. Provide all refrigeration equipment and related installation in compliance with the latest editions of the Mechanical Code of NYS chapter 11, the safety code for mechanical refrigeration ASHRAE Standard 15, and ANSI Refrigeration Safety Code B 9.1.

1.4 SUBMITTALS

- A. Comply with requirements of Section 01 33 00 "Submittal Procedures" and as modified below.
- B. Product Data: Provide manufacturer's specification data for each unit, showing operating weight, all sizes, dimensions, capacity, operating and performance characteristics, motor horsepower, and other pertinent data including color chart.
- C. 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 DUCTLESS SPLIT COOLING ONLY OR HEAT/COOL AIR CONDITIONING UNIT

- A. Unit Description: Unit bearing AHRI Certification Symbol and listed by ETL Testing Laboratories, Inc. consisting of outdoor unit which contains refrigerant compressor and can provide cooling only or heating and cooling of spaces, indoor unit connected by insulated copper refrigerant tubing with flare type fittings. System equipped with factory-installed solid core filter drier, large capacity suction accumulator, low ambient controls, and other accessories as specified and as scheduled.
 - 1. Cooling only units similar to ductless heat/cool heat pump units without capability for reversing heat flow – ie., no reversing valve and associated controls.
 - 2. Refrigerant Run Capability: 130 feet of lift with maximum tubing length of 130 feet of interconnecting piping for up to 1.5 ton capacity unit, and 50 feet of lift with maximum tubing length of 164 feet for unit with greater than 1.5 ton capacity up to 3.5 ton capacity.
 - 3. Refer to drawings for capacities and performance ratings.
- B. Refrigerant: Sufficient R454B refrigerant provided in outdoor unit to charge complete system.
- C. Outdoor Condensing Unit: Outdoor with inverter driven variable speed compressors which provides efficient cooling and heating performance.
 - 1. General data:
 - a. Factory assembled and pre-wired with all necessary electronic and refrigerant controls.
 - b. Refrigeration circuit consisting of a digital scroll compressor, motors, fans, condenser coil, electronic expansion valve, solenoid valves, 4 way valve, distribution headers, capillaries, filters, service isolation valves, oil separators, service ports, liquid receivers and accumulators.
 - c. Both liquid and suction lines must be individually insulated between the outdoor and indoor units on heat pump units. Liquid line insulation is not required on cooling only units.
 - d. The outdoor unit can be wired and piped with outdoor unit access from left, right, rear or bottom.
 - e. The sound pressure at rated conditions: maximum of 58 decibels dB(A) at 3 feet from the front of the unit. Provide with night operation mode capable of operating at further reduced noise.
 - f. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for re-programming.

- g. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
 - h. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers, and sub-cooling feature. Oil recovery cycle shall be automatic occurring 1 hour after start of operation and then every 6 hours of operation.
 - i. The outdoor unit shall be capable of full heat pump heating operation at 0°F dry bulb ambient temperature without additional low ambient controls. Provide for 100% heat pump heating capacity down to minus 4 deg F, with partial capacity heat pump operation down to no greater than minus 13 deg F.
- 2. Unit Cabinet:
 - a. The outdoor unit shall be completely weather proof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
- 3. Fan:
 - a. The outdoor unit shall consist of one or two propeller type, direct-drive fan motors that have multiple speed operation via a DC inverter.
 - b. The outdoor unit fan motor shall have multiple speed operation of the DC inverter type, controlled to modulate as required to maintain head pressure.
 - c. The fan motor shall have internal thermal overload protection and permanently lubricated bearings and be mounted on rubber in shear isolators.
 - d. Provide a fan guard to prevent contact with moving parts, constructed of welded wire and plated or painted for corrosion resistance.
- 4. Outdoor Coil:
 - a. Manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
 - b. The coil shall be of a waffle louver fin and high heat exchanger, rifled bore tube design to ensure highly efficient performance.
 - c. The coils shall be complete with corrosion treatment of an acrylic resin type. The thickness of the coating must be between 2.0 to 3.0 microns.
- 5. Compressor:
 - a. The scroll compressor shall be variable speed (PWM inverter) controlled, changing speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.
 - b. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC, hermetically sealed scroll type with a maximum speed of 6,480 rpm.

- c. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
 - d. The capacity control range shall be modulating from 14% to 100%.
 - e. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
 - f. Oil separators shall be standard with the equipment together with an oil balancing circuit.
 - g. The compressor shall be mounted to avoid the transmission of vibration.
6. Electrical:
- a. The power supply to the outdoor unit shall be in voltage and phasing as shown on the drawings, with a tolerance of +/- 10% from nominal indicated.
 - b. The control voltage between the indoor and outdoor unit shall be low voltage control wiring compatible with the energy management and control system as specified in section 23 09 00. The control wiring shall be a multiplex communication system, making it possible to connect multiple indoor units to one outdoor unit with one cable, thus simplifying the wiring operation.

D. Indoor Unit – Ceiling Cassette Unit

- 1. General: The indoor unit model shall be a ceiling cassette fan coil unit, operable with scheduled refrigerant, for installation into the ceiling cavity with an air panel grille. It shall be a four-way air distribution type, ivory white, impact resistant, and washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized control shall be used to maintain room temperature within 1°F. The indoor units sound pressure shall range from 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
- 2. Indoor Unit:
 - a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 - b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
 - c. Both refrigerant lines shall be insulated from the outdoor unit.
 - d. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.

- e. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
 - f. Indoor units shall be capable of accepting outside air delivered through sidewall knock-outs sized for acceptance of scheduled outside air flow rates.
 - g. The indoor units shall be equipped with an insulated corrosion proof condensate pan under the coil capturing and controlling all condensate.
 - h. Provide a condensate pump with a 21 inch lift located below the coil in the condensate pan, complete with a built in safety high level alarm and interlock.
 - i. The indoor units shall be equipped with a return air thermistor.
 - j. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
 - k. The voltage range will be 253 volts maximum and 187 volts minimum.
3. Unit Cabinet:
- a. The cabinet shall be space saving and shall be located into the ceiling.
 - b. Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.
 - c. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
 - d. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
4. Fan:
- a. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.
 - b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range from 0.06 to 0.12 HP.
 - c. The air flow rate shall be available in high and low settings.
 - d. The fan motor shall be thermally protected.
5. Filter:
- a. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
6. Coil:
- a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
 - c. The coil shall be a 2 row evaporator coil completely factory tested.
 - d. A thermistor will be located on the liquid and gas line.

7. Electrical:

- a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
- b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
- c. Transmission (control) wiring between the indoor and remote controller shall be a maximum distance of 1,640 feet.

8. Control:

- a. The unit shall have controls provided to perform input functions necessary to operate the system.
- b. The unit shall be compatible with interfacing with connection to LonWorks networks or interfacing with connection to BMS system.

E. Controls:

1. Provide intelligent touch controller to control entire system. Provide gateway to seamlessly interface with EMCS.
2. Provide Simplified wired remote controller for each space. All room controllers to wire to intelligent touch controller which can be monitored at the OWS.

F. Manufacturers:

1. Basis of design is as scheduled on the drawings.
2. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Carrier / Toshiba.
 - b. Daikin.
 - c. Sanyo.
 - d. Trane / Mitsubishi.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine conditions under which unitary air conditioning equipment is to be installed 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 an acceptable manner.
1. When conditions are confirmed to be 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.

3.2 INSTALLATION

- A. Install in strict accordance with manufacturer's recommendations and as follows.
 - 1. 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.
- B. Provide all required supports, attachment devices, vibration isolators, gasketing, sealants, and accessories needed to insure stable, quiet, leak free operation.
- C. Provide all refrigerant piping in strict accordance with section 23 23 00 "Refrigerant Piping".
- D. Run insulated condensate drain line to approved point of indirect waste disposal through properly sized P-trap. Pitch drain line continuously in direction of flow. If gravity drain is not possible, provide condensate removal pump as specified, piped to nearest approved point of indirect waste disposal.

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. Measure and check voltage of components.
 - 2. Check removal of shipping bracing.
 - 3. Proper connection of drains.
 - 4. Check control circuitry, operation, and performance during all modes of operation.
 - 5. Fan check (RPM, motor amps, rotation, belt tension, etc.).
 - 6. All wiring circuits.
 - 7. All accessory equipment operation, such as filters, controls, condensate drain, etc.

END OF SECTION 23 62 13

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.
 - 2. Refrigerant condensing units shall be of the same manufacturer as the indoor unit

1.4 SUBMITTALS

- A. Comply with requirements of Section 01 33 00 "Submittal Procedures" 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. ODU 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 Copeland 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: Daikin
 2. Specified equivalents:
 - a. Daikin or equal.
 - b. Carrier or equal.
 - c. Trane 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.
 - 2. Units larger than 3 tons capacity: Install roof mounted condensing units on equipment support rails as detailed. Provide pipe penetration curb for refrigerant piping and electrical penetrations of roofing. Install vibration isolation on all roof mounted units and piping
- 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 72 00 - AIR-TO-AIR ENERGY RECOVERY 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. Packaged energy recovery units.

1.3 PERFORMANCE REQUIREMENTS

- A. No condensate shall form anywhere on or around the complete unit that is not controlled by condensate pans and directed to drain through condensate piping provided as a part of this Contract.

1.4 SUBMITTALS, GENERAL

- A. General: Submit all action submittals and informational submittals required by this Section concurrently.
- B. Product Data: For each type or model include the following:
 - 1. Complete fan performance curves for both Supply Air and Exhaust Air, with system operating conditions indicated, as tested in an AMCA certified chamber.
 - 2. Sound performance data for both Supply Air and Exhaust Air, as tested in an AMCA certified chamber.
 - 3. Motor ratings, electrical characteristics and motor and fan accessories.
 - 4. Performance ratings for DX and hot water coils.
 - 5. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
 - 6. Estimated gross weight of each installed unit.
 - 7. Installation, Operating and Maintenance manual (IOM) for each model.
 - 8. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
 - 9. Energy recovery performance data for both summer and winter operation.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For air-to-air energy recovery equipment. 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 CLOSEOUT SUBMITTALS

- A. Field quality-control reports.
- B. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AHRI Compliance:
 - 1. Capacity ratings for air-to-air energy recovery equipment shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
 - 2. Capacity ratings for air coils shall comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
- C. ASHRAE Compliance:
 - 1. Applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
 - 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- E. UL Compliance:
 - 1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
 - 2. ETL listed and wired according to the NEC with UL listed power components.

- F. Unit shall comply with NFPA 90A requirements for flame spread and smoke generation, including the unit insulation.
- G. Air flow data shall be in accordance with AMCA 210 testing method.

1.8 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Packaged Energy Recovery Units: One year.
 - 2. Warranty Period for Energy Wheel Heat Exchangers: 10 years.

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. Filters: One set of each type of filter specified.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Acceptance at Site
 - 1. Inspect the factory packaging before opening and note any damage on the packing slip. Unpack and inspect the unit before acceptance. Dents or scratches of the casing of the unit, or substantial damage to the packing materials that may indicate internal damage to the unit, shall be cause for rejection of the unit.
- B. Storage and Protection
 - 1. After acceptance on site, until such time as the unit is being actively installed, package the unit in protective materials and stored in a protected location so as to protect the function and appearance of the unit in the as accepted condition.

PART 2 - PRODUCTS

2.1 ENERGY RECOVERY AIR HANDLERS

A. Manufacturers

1. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
 - a. Valent Air Corporation, LLC
 - b. Des Champs Technologies.
 - c. Greenheck Fan Corporation.
 - d. RenewAire LLC.
 - e. SEMCO Incorporated.

B. Manufactured Units

1. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, downturn outdoor air intake with 2" aluminum mesh filter assembly, exhaust air blower, evaporator coil, energy wheel, hot water coil, hot gas reheat coil, packaged DX system, phase and brownout protection, motorized dampers, motorized recirculating damper, curb assembly, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection except with electric post heat and exhaust fan only power which have dual point power.

C. Cabinet

1. Materials: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
2. Unit's exterior shall be supplied from the manufacturer using G60 galvaneal steel with proprietary pre-painted material in the following finish color; Concrete Gray-RAL 7023. This has been subjected to a salt spray test per ASTM-B117 and evaluated using ASTM-D714 and ASTM-D610 showing no observable signs of rust or blistering until reaching 2,500 hours. Uncoated galvanized steel exterior is not acceptable.
3. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.
4. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
 - a. Materials: Rigid urethane injected foam. Foam board not acceptable.
 - 1) Thickness: 2 inch (50.8 mm)
 - 2) Thermal Resistance R13
 - 3) Thermally broken

- 4) Meets UL94HF-1 flame requirements.
 - 5) Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.
5. Roof Insulation: 2 inch (50.8 mm) fiberglass located above the 1 inch (25.4 mm) foam panel.
6. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvanized steel.
- D. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.
- E. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.
- F. Evaporator Coil: Evaporator coil shall be (silver) soldered or brazed into the compressed refrigerant system. Coil shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame. If two compressors are used as components of the unit, then the evaporator coil shall be of "interlaced" configuration, permitting independent operation of either compressor without conflict with the other compressor.
- G. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. RTU shall be equipped with a Unit Disconnect Switch.
- H. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.
- I. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.

- J. Energy wheel: Bypass dampers are only acceptable during economizer operation – they cannot be used during normal operation. Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt or a link style belt with a five-year warranty. The wheel media shall be a polymer film matrix in a stainless-steel framework and be comprised of individual segments that are removable for servicing. Energy wheel motor shall be variable speed. Non-segmented energy wheels are not acceptable. Silica gel desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five-year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.
- K. Modulating frost control. Control system shall include an outdoor air thermostat and pressure sensor on the wheel assembly to initiate frost control sequence.
- L. Indirect gas furnace
1. Shall be ETL Certified as a component of the unit.
 2. Shall have an integral combustion gas blower.
 3. Shall be ETL Certified for installation downstream of a cooling coil.
 4. Shall have fault sensors to provide fault conditions to optional digital controller or building controls.
 5. Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.
 6. Heat exchanger shall have a 25 year extended warranty.
 7. Furnace control shall be HighTurndown 16:1 .
 8. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.
 9. Shall have solid state controls permitting stand-alone operation or control by building controllers.
- M. Reheat coil with factory installed modulating hot gas reheat valve.

- N. Packaged DX System: Unit shall have an integral compressor(s) and evaporator coil located within the weather-tight unit housing. Condenser coils and appurtenant condenser fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Lead condenser fan shall have EC motor to maintain condenser pressure at part load conditions. Motors shall be UL Recognized and CSA Certified. The lead refrigerant compressor(s) shall be inverter hermetic scroll-type and shall be equipped with liquid line filter drier, thermostatic expansion valves (TXV)(s), manual reset high pressure and low pressure cutouts and all appurtenant sensors, service ports and safety devices. Compressed refrigerant system shall be fully charged with R-410A refrigerant. Compressors shall be mounted within an insulated access compartment and on a raised cabinet shelf to reduce sound and vibration. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil.
- O. Condenser Fans: Fan blades must be constructed of aluminum or a composite material and have a geometry designed and documented to reduce sound and energy when compared to a traditional rectangular blade fan. Traditional rectangular blade fans are not allowed due to increased noise generated and increase power utilized. Condenser fan motors shall be three phase, external rotor, type 56 frame, open air over and shaft up. Each condenser fan motor shall have a vented frame, rated for continuous duty and be equipped with an automatic reset thermal protector. Lead condenser fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a head pressure set point.] Motors shall be UL Recognized and CSA Certified. Single condenser fan running at max RPM and design static pressure shall not exceed an A-weighted sound power level of 75 db at free inlet/outlet test conditions.
- P. Packaged DX Control and Diagnostics: The Packaged DX system shall be controlled by an onboard digital controller (DDC) that indicates both owner-supplied settings and fault conditions that may occur. The DDC shall be programmed to indicate the following faults:
1. Global alarm condition (active when there is at least one alarm)
 2. Supply Air Proving alarm
 3. Dirty Filter Alarm
 4. Compressor Trip alarm
 5. Compressor Locked Out alarm
 6. Supply Air Temperature Low Limit alarm
 - a. Sensor #1 Out of Range (outside air temperature)
 - b. Sensor #2 Out of Range (supply air temperature)
 - c. Sensor #3 Out of Range (cold coil leaving air temperature)
 - d. Phase and brownout protection: Unit shall have a factory-installed phase monitor to detect electric supply phase loss and voltage brown-out conditions. Upon detection of a fault, the monitor shall disconnect supply voltage to all motors.

- Q. Motorized dampers / Intake Air, Exhaust Air, Motorized dampers of low leakage type shall be factory installed.
- R. Curb Assembly: A curb assembly made of 14 gauge galvanized steel shall be provided by the factory for assembly and installation as part of this division. The curb assembly shall provide perimeter support of the entire unit and shall have duct adapter(s) for supply air and return air. Curb assembly shall enclose the underside of the unit and shall be sized to fit into a recess in the bottom of the unit. Contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly. The curb shall be the height of 18 in.
1. Hail Guards: Protects the condensing unit from damage due to extreme weather conditions such as hail and flying debris.
- S. Blower
1. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.
 2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
 3. Fan: Direct drive, airfoil plenum fan with aluminum wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.
 4. Blades: Welded aluminum blades only.
 5. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".
- T. Motors
1. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPart minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.
 2. Motors shall be 60 cycle, 3 phase 208 volts.
- U. Unit Controls
1. The unit will be provided with factory mounted controls with a BACnet interface.

2. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.
3. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.
4. Unit supply fan shall be configured for Variable Volume.
5. Unit exhaust fan shall be configured for damper tracking.
6. Outside Air / Return Air damper control shall be field adjustable two-position.
7. Economizer control shall be temperature.
8. Dirty filter sensor shall be factory installed.
9. Operating protocol: The DDC shall be factory-programmed for BACnet MSTP.
10. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

V. Filters

1. Unit shall have permanent 2 inch (50.8 mm) aluminum filters located in the outdoor air intake and return and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the supply air stream. MERV 13 disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream.

2.2 PACKAGED 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. Applied Air; Mestek Technology, Inc.
2. Carnes.
3. Greenheck Fan Corporation.
4. Loren Cook Company.
5. RenewAire LLC.
6. Trane; American Standard Companies, Inc.

- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, hinged access doors, removable panels with neoprene gaskets for inspection and access to internal parts, minimum 2 inch thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
- D. Heat Recovery Device: Fixed-plate heat exchanger.
- E. Supply and Exhaust Fans: Forward-curved, centrifugal fan with spring isolators and insulated flexible duct connections.
 - 1. Motor and Drive: Drive type indicated on Drawings.
 - 2. 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."
 - 3. 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.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
 - 5. Spring isolators on each fan having 1 inch static deflection.
- F. Disposable Panel Filters:
 - 1. Comply with NFPA 90A.
 - 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 - 3. Factory-fabricated, viscous-coated, flat-panel type.
 - 4. Thickness: 2 inches.
 - 5. Minimum Arrestance: 80, according to ASHRAE 52.1.
 - 6. Minimum Merv: MERV8, according to ASHRAE 52.2.
 - 7. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
 - 8. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

- G. Wiring: Fabricate units with space within housing electrical conduits. Wire motors and controls so only external connections are required during installation.
 - 1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
 - 2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
 - 3. Include fused disconnect switches.
 - 4. Variable-speed controller to vary fan capacity from 100 to approximately 50 percent.
- H. Accessories:
 - 1. Duct flanges.
 - 2. Rubber-in-shear isolators for ceiling-mounted units.
 - 3. Hinged access doors with quarter-turn latches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for electrical services to verify actual locations of connections before 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. Equipment Mounting: Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Specialties." Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing.
- B. Install units with clearances for service and maintenance.
- C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- D. Pipe drains from units to roof; use same size as condensate drain connection.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
- E. Hot Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Comply with requirements for ductwork specified in Division 23 Section "Ductwork."
- G. Electrical Connections: Comply with applicable requirements in Division 26 Sections.
 - 1. Install electrical devices furnished with units but not factory mounted.

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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Adjust seals and purge.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Set initial temperature and humidity set points.
 - 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 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. Fin Tube Radiation (FTR),
 - 3. Cabinet Unit Heaters (CUH),
 - 4. Air Coils (RHC),

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 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Ceiling suspension components.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.

4. Size and location of access panels in hard ceilings to provide access to concealed units.
 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 6. Perimeter moldings.
- B. Manufacturer Seismic Qualification Certification: Submit certification that unit ventilators, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 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. Warranty: Special warranty specified in this Section.

1.6 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.

1.7 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."

1.8 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.

1.9 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 3 spare filter(s) for each filter installed.
 - 2. Fan-Coil Filters: Furnish 3 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. 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.

- 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.

<u>Unit Size</u>	<u>Motor Speed</u>	<u>SOUND POWER DATA (db re: 10⁻¹² watts)</u>						
	<i>Octave Band:</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>
	<i>Center Frequency:</i>	<i>125</i>	<i>250</i>	<i>500</i>	<i>1000</i>	<i>2000</i>	<i>4000</i>	<i>8000</i>
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.

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.
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.
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.
 - 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.

9. Surfaces in contact with the airstream: Comply with requirements in ASHRAE 62.1.

10. Provide a durable Charcoal Bronze textured paint finish on the top surface. Provide front end, and all other visible panels with baked enamel finish available in a minimum of (6) decorator colors for selection by the Architect.

F. Ceiling Units:

1. Similar in construction and finish to floor units with the following differences:

- a. Provide two hinged bottom panels for ease of handling. Provide with retainer chains to prevent sudden release of the bottom panels.
- b. Discharge, return, and outside air intake openings fitted with the following trim, as scheduled and as coordinated with the drawings, Owner, and Architect in the field:
 - 1) Unit concealed above ceiling: three duct collars.
- c. The center line of the cooling condensate drain shall be a minimum of 4.5 inches above the bottom of the unit.
- d. Provide trim flange for recessed units. The trim flange shall be 3-sided or 4-sided as required.

G. Coils:

1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
3. Indoor Refrigerant Coils: (3) or (4) rows deep, as scheduled, copper finned tube coils with 3/8" O.D. nominal, seamless copper tubing, mechanically bonded aluminum fins spaced no closer than 0.1 inch continuous across all tubes, and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Provide with thermostatic expansion valve and distributor and quick connect refrigerant couplings. Provide factory dehydrated, evacuated, and charged with operating charge of specified refrigerant, hermetically sealed for use with the VRF system.

4. Coil Accessories:

- a. Provide a Stainless Steel, all-aluminum, or galvanized steel with plastic liner drain pan beneath all coils to collect all condensate and leakage, formed as required by ASHRAE 62.1, easily removable for cleaning purposes, and drained at the unit end compartment to the condensate disposal system. Insulate the condensate drain pan to prevent external condensation.

H. Dampers

1. Provide with return air, outdoor 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.

I. 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). 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.

J. 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, speed selector switch as applicable, 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. Additional control devices and operational sequences are specified in Division 23 Section "Instrumentation and Control for HVAC" and on the drawings.

K. Accessories

1. Pipe Compartment:
 - a. Provide piping enclosures by UV manufacturer for all vertical units. Pipe compartment shall be installed adjacent to the unit ventilator as indicated on plan view drawings.
 - 1) Pipe compartment shall serve as a control enclosure for VRF system unit controller.
 - 2) Dimensions shall match unit depth and height. Length shall be 18".
2. Filters:
 - a. 1 inch thick mini-pleated cotton-polyester media MERV 13 filters with a rating based on ASHRAE Standard 52.2.
3. Provide a factory installed automatic reset freeze-stat (refer to section 23 09 00 for specification) serpentine 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.
4. Outside Air Intake:
 - a. Provide outdoor air intakes of vertical blade louver design, of aluminum construction, 2-1/4" deep in the direction of the air flow, with weep hole along bottom edge for drainage.

- b. Provide 1/2" x 1/2" bird screen on inside face of louver, and 12 gauge aluminum outdoor protective grille with square holes of spacing to match louver blades, connected by 1/4" wide frets aligned with louver blades to minimize intake air obstruction.
- c. Provide scheduled factory finish as detailed below.
 - 1) Standard mill finish.
- d. Provide galvanized sheet metal OA intake sleeve from louver to unit back complete as detailed and as required to effect airtight seal to unit, in accordance with specification section 23 31 00 "Ductwork".
- e. Provide intakes by unit ventilator manufacturer except as otherwise noted on the Drawings. Provide manufacturer's standard size intake for that size UV unless indicated otherwise on drawings.

2.2 CABINET UNIT HEATERS

- 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. McQuay International.
 - 3. Trane.
- B. Description: A factory-assembled and -tested unit complying with AHRI 440.
 - 1. Comply with UL 2021.
- C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.
 - 1. Thickness: 1 inch.
 - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
 - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
 - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch thick, galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain, fitted with stamped steel bottom inlet and discharge grilles where shown without connecting ductwork.
 3. Recessing Flanges: Steel, finished to match cabinet.
 4. Control Access Door: Key operated.
 5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.
 6. Extended Piping Compartment: 8-inch wide piping end pocket.
 7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.
- E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
 2. Pleated: 90 percent arrestance and 7 MERV.
- F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- G. Fan and Motor Board: Removable.
1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Electrical Requirements for HVAC Equipment."
 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- H. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC".

2.3 HOT-WATER FINNED TUBE RADIATION

- 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. Fin Radiation: Complete enclosure of heavy-duty, institutional grade construction, continuous supporting channel and back plate, 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" 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.
 - 1) For all fin tube shown with 4-1/2" nominal enclosure and as bare element in casework, provide element with fifty 4" x 4" aluminum fins per foot with single element nominal capacity of 1680 btu/ft-hr. at 65 deg. F entering air temperature and hot water at EWT 180 deg. F, LWT 160 deg. F.
 2. Fin Tube Enclosure types:
 - a. Type B: Wall mounted slope top enclosure nominally 4-1/4" deep x 24" high (unless noted otherwise), with stamped slotted sloped front supply grille.
 3. 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.
 - c. Material gauges:
 - 1) 16 ga.: General 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.

2.4 HEATING COILS FOR AIR SYSTEMS

A. General:

- 1. Size for face velocity and maximum pressure drops scheduled. If not scheduled, size to provide maximum of 500 fpm face velocity for cooling coils, 650 fpm face velocity for heating coils, or higher only if restricted by maximum coil size that can fit within existing units.
- 2. All coils to be computer optimized as to size and arrangement to meet requirements listed on drawings. Include computer selection sheets in submittal.
- 3. Certified in accordance with AHRI Standard 410.
- 4. Rate coils for the type and percentage of glycol solution called for, where applicable.

B. Hydronic Heating Coils:

- 1. Coils shall have all performance characteristics as scheduled or otherwise required as a minimum, including size, sensible and latent capacity, number of rows, tubing and circuits, headers, connection sizes, and water and air pressure drops.
- 2. Casings: Constructed of 16 gauge channels with fins tight against or recessed into the channels to minimize air bypass. Channels to have 3/8" holes on 6" centers for flanged to duct mounting. Where required by different existing duct connection conditions, provide flange mounting arrangement to match existing.
 - a. Coils shall have continuously galvanized steel casing frames.

3. Headers:
 - a. Provide copper, steel, or cast iron headers as required to achieve capacity, even discharge air temperatures, and water pressure drop scheduled.
 - 1) Seamless extra heavy wall copper tubing with brazed brass threaded supply and return connections.
 - 2) Gray cast iron hydrostatically tested to 400 PSIG before assembly. Headers 12 inch and larger shall be tapered to assure uniform distribution to all tubes. Provide threaded or flanged connections.
 - 3) Provide system connection sizes same size as connected piping as shown on drawings, unless otherwise scheduled.
 - 4) Provide drain and vent connections in headers.
4. Tubes, unless otherwise scheduled:
 - a. Seamless, 5/8" O.D., 0.024 inch min. wall copper tube primary surface, expanded into the fin collars for a permanent fin tube bond and brazed copper header into the header for a leak tight joint at 250 PSIG air pressure under water.
 - b. Return bends shall be .035" min. wall machine die formed and wrinkle free at the bend I.D.
5. Fins:
 - a. Continuously configured .006" min. plate type fins with full fin collars for accurate spacing and maximum fin - tube contact.
 - b. General heating coil fin material: aluminum.
 - c. Cooling coil, and as otherwise noted on drawings, fin material: Heresite coated aluminum or copper.
6. The complete coil core shall be tested with 315 psi min. air (or nitrogen) pressure under warm water and guaranteed for 250 psig working pressure.
7. Bronze spring type turbulators shall be used where necessary to attain required capacity at the available GPM and entering water temperature, without increase in scheduled water pressure drop.
8. Manufacturers: 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. Carrier or equal
 - b. Enviro-tec or equal
 - c. Heatcraft Refrigeration Products LLC; Heat Transfer Division.
 - d. McQuay or equal.
 - e. Super Radiator Coils.
 - f. Trane or equal

- g. USA Coil & Air.

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 and minimum 0.25-inch static-deflection, elastomeric vibration isolation hanger.
- 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. 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.

- C. After installing equipment, inspect for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- D. 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 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. Lighting.
 - 3. 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. Lighting.
 - d. 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. 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.
 - 2. Coordinate and schedule time and place of all training through the Architect at the Owner's convenience.
 - 3. 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.
 - 4. Architect's representative must be present when Owner's representatives participate in instruction.

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.

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 Waste 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 27 15 00 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 CLOSEOUT 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. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- D. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway
- G. Branch Circuits in Cable Tray: Metal-clad cable, Type MC.
- H. 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 26 05 33 "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 26 05 29 "Hangers and Supports for Electrical Systems."
- N. Complete cable tray systems installation according to Section 26 05 36 "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 26 05 53 "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 26 05 44 "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 07 84 13 "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: Before Substantial Completion, 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 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.
- B. Field quality-control reports.

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.

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.

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 (600 mm) below grade.
- C. 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 Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.

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. 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.
- F. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

- A. 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. 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.
- C. 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. Bond each above ground portion of gas piping system downstream from equipment shutoff valve.
- D. 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.

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.

- 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).
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
- F. Provide all test and inspection reports with closeout submittals.

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 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 ACTION 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. Pduuit 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 1/2" 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, conduit 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. Outlet boxes designed for attachment of luminaires weighing more than 50 lb 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. Minimum Raceway Size: 1/2-inch (16-mm)

- I. 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.
- J. Raceways for Future Use (Spare Raceways and Empty Raceways): Draw fish tape through raceways to confirm that raceway is clear of obstructions. Leave pulling-in line in each spare and empty raceway.
- K. 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.
- L. 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.

M. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

N. 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 31 20 00 "Earth Moving" for pipe less than 6 inches in nominal diameter or as detailed on drawings.
2. Install backfill as specified in Section 31 20 00 "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 of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 31 20 00 "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 of concrete for a minimum of 12 inches 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 from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

3.3 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.

3.4 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.

3.5 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, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and 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. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. 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.
- F. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
- G. 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 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.

2.4 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."

2.5 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.

2.6 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.

2.7 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.

2.8 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. 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.
- B. 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.
- C. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- D. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- E. 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.
- F. 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.
- G. 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.
- H. 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.
- I. 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.
- J. 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.
- K. 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. 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.
- c. 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.
- d. 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".
- e. 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.

- f. 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”.
 - g. Emergency Lighting Fixtures:
 - 1) 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.

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 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 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. Low voltage controls.
4. Conductors and cables.

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. Casambi
 - 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. Casambi
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 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. Casambi
 2. Leviton.
 3. Steinel.
- 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 Colors.
 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, Behavior 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.

2.4 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "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 26 05 19 "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 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 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 01 78 23 "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.
 - 3. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing
 - 4. Field test reports.

1.5 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces.
- B. 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.
- C. Incoming Mains Location: Top or bottom as required.
- D. 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.

- E. 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.
- F. 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.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 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. 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.

2.3 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. 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.

2.4 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. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. 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.
- D. Mount panelboard cabinet plumb and rigid without distortion of box.
- E. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- F. Install overcurrent protective devices and controllers not already factory installed.
- G. 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.
- H. Install filler plates in unused spaces.

- I. Stub two 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub two 1-inch empty conduits below slabs not on grade.
- J. 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 26 05 53 "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 26 05 53 "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 26 05 53 "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: Prior to Substantial Completion Inspection 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.
- F. Include test reports in Closeout Submittals.

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, controlled receptacles, and associated device plates.
 - 2. Tamper-resistant receptacles.
 - 3. Weather-resistant 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. 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 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.
- B. Field Quality Test Reports.

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. 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.

2.4 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. 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; 2097-TR.
 - c. Leviton; T5320.

C. Weather-Resistant, Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20A:

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. Leviton; GFWR2-W.
 - b. Pass & Seymour; 2097-TRWR
 - c. Hubbell; GFRTW20.

2.5 WIRED HALF-CONTROLLED DUPLEX STRAIGHT-BLADE RECEPTACLE

A. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

1. Receptacles with Integral Switching Means: UL CCN RTXI and UL Subject 498B.

Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Leviton; TBR20-S1G
- b. Pass & Seymour; TR8300HCHGRY
- c. Hubbell; BR20C1GRY.

2.6 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.

2.7 FINISHES

- A. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: Gray or As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including 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. Pigtail 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. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.

H. 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 IDENTIFICATION

- A. Comply with Section 26 05 53 "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.

3.4 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 and provide with Closeout Submittals.

END OF SECTION 26 27 26

SECTION 26 31 00 - PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Photovoltaic (PV) systems description.
2. Manufactured PV units.
3. PV module framing.
4. PV array construction.
5. Inverters.
6. System overcurrent protection.
7. Mounting structures.

1.2 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 PV panels.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For PV modules.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A.** Field quality-control reports.
- B.** Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

1.4 CLOSEOUT SUBMITTALS

- A.** Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
- B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.
 - 1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:
 - a. Specified minimum power output to 80 percent or more, for a period of 25 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled by a qualified testing agency and marked for intended location and application.

2.2 PV CAPACITIES AND CHARACTERISTICS

- A. Minimum Electrical Characteristics:
 - 1. Rated Open-Circuit Voltage: 42.83 V dc.
 - 2. Maximum System Voltage: 1000 V dc.
 - 3. Maximum Power at Voltage (V_{pm}): 35.98 V dc.
 - 4. Rated Short-Circuit Current (I_{sc}): 9.05.
 - 5. Maximum System: 1000 V dc.
 - 6. Rated Operation Current (I_{mp}): 8.68.
 - 7. Maximum Power at STC (P_{max}): 311.3.
- B. Normal Operating Temperature Characteristics (NOTC):
 - 1. Temperature at Nominal Operating Cell Temperature: 43 deg C.
 - 2. Temperature Coefficient (NOTC Nominal Power): -0.34 deg C.
 - 3. Temperature Coefficient (NOTC Open-Circuit Voltage): -0.27 deg C.
 - 4. Temperature Coefficient (NOTC Short Circuit Current): +0.04 deg C.

2.3 PV SYSTEMS DESCRIPTION

- A. Interactive PV System: Collectors connected in parallel to the electrical utility; and capable of providing power for Project and supplying power to a distributed network.
 - 1. A twelve-module array to generate a total nominal rated output of 4,980 **W**.
 - 2. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Utility-interactive inverter.
 - d. Overcurrent protection, disconnect, and rapid shutdown devices.
 - e. Mounting structure.
 - f. Utility meter.

2.4 MANUFACTURED PV UNITS

- A. Cell Materials: Amorphous silicon (a-Si).
- B. Cell Materials: Micromorphous silicon (a-Si+uc-Si).
- C. Cell Materials: Copper indium (di)selenide (CIS).
- D. Cell Materials: Copper indium gallium (di)selenide (CIGS).
- E. Cell Materials: Cadmium telluride (CdTe).
- F. Cell Materials: Cadmium sulfide.
- G. Cell Materials: Monocrystalline.
 - 1. c-Si.
 - 2. Gallium arsenide (GaAs).
- H. Module Construction:
 - 1. Nominal Size: 41.1 inches wide by 74 inches long.
 - 2. Weight: 48.5 lb.
- I. Insulating Substrate Film: Flexible.
- J. Conducting Substrate Film: Flexible.
- K. Encapsulant: Ethyl vinyl acetate.
- L. Front Panel: 0.13-inch- thick thermally pre-stressed glass with anti-reflection technology.

- M. Backing Material: Composite film.
- N. Bypass Diode Protection: Internal.
- O. Junction Box:
 - 1. Size: 1.56 by 3.96 by 0.52 inch.
 - 2. Fully potted, vandal resistant.
 - 3. IP Code: IP65.
 - 4. Flammability Test: UL 1703.
- P. Output Cabling:
 - 1. 0.158 inch.
 - 2. Quick, multiconnect, polarized connectors.
 - 3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.
- Q. Series Fuse Rating: 20A.

2.5 PV MODULE FRAMING

- A. PV laminates mounted in anodized extruded-aluminum frames.
 - 1. Entire assembly UL listed for electrical and fire safety, Class A, according to UL 1703, and complying with IEC 61215.
 - 2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
 - 3. Finish: Anodized aluminum.
 - a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
 - b. Color: As indicated by manufacturer's designations.

2.6 PV ARRAY CONSTRUCTION

- A. Framing:
 - 1. Material: Galvanized steel.
 - 2. Maximum System Weight: Less than 6.89 lb/sq. ft.
 - 3. Raceway Cover Plates: Galvanized steel.
- B. Flat-Roof Mounting:
 - 1. No roof penetrations.
 - 2. Self-ballasting.
 - 3. Wind-tunnel tested to 115-mph wind.
 - 4. Service Life: 25 years.
 - 5. Freestanding system.

2.7 INVERTER

- A. Inverter Type: Central.
- B. Control Type: Pulse-width-modulation control.
- C. Inverter Electrical Characteristics:
 - 1. Maximum Recommended PV Input Power: 4.8 kilowatts.
 - 2. Maximum Open-Circuit Voltage: 600 V dc.
 - 3. PV Start Voltage: 60 V dc.
 - 4. MPPT Voltage Range: 112-480 V dc.
 - 5. Maximum Input Current: 15A.
 - 6. Number of String Inputs: 2.
 - 7. Number of Independent MPPT Circuits: 2.
 - 8. Nominal Output Voltage: 208 V.
 - 9. CEC Rated Power: 4800 VA.
 - 10. Nominal Output Voltage: 208 V ac.
 - 11. Maximum Output Current: 20A.
 - 12. Peak Efficiency: 98.1 percent.
 - 13. CEC Weighted Efficiency: 97 percent.
 - 14. DC/AC Terminal Range (AWG): #12-10 AWG.
 - 15. Communications Interface: Ethernet.
 - 16. Utility Interface: Utility-interactive inverter.
- D. Operating Conditions:
 - 1. Operating Ambient Temperatures: Minus 13 to plus 140 deg F.
 - 2. Storage Temperature: Minus 40 to plus 140 deg F.
 - 3. Relative Humidity: Zero to 95 percent, noncondensing.
- E. Enclosure:
 - 1. NEMA 250, Type 3R.
 - 2. Enclosure Material: Galvanized steel.
 - 3. Cooling Methods:
 - a. Natural convection cooling.
 - 4. Protective Functions:
 - a. AC over/undervoltage.
 - b. AC over/underfrequency.
 - c. Ground overcurrent.
 - d. Overtemperature.
 - e. AC and dc overcurrent.
 - f. DC overvoltage.
 - g. DC Arc Fault Protection.

- 5. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.
- F. Disconnects: Rated for system voltage and conductor.
- G. Regulatory Approvals:
 - 1. IEEE 1547.1.
 - 2. IEEE 1547.3.
 - 3. UL 1741.
- H. Characteristics:
 - 1. Inverter Dimensions: 19.7 x 23.1 x 9.2 in.
 - 2. Inverter Weight: 38.6 lb.

2.8 SYSTEM OVERCURRENT PROTECTION

- A. Circuit Breakers: 30A.

2.9 MOUNTING STRUCTURES

- A. Roof Mount: Extruded aluminum, two rails, tilt legs, and roof standoffs.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Do not begin installation until mounting surfaces have been properly prepared.
- C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
- E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of PV panels with roof assembly and other construction.
- C. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.

- D. Install PV inverters, in locations indicated on Drawings.
- E. Install weatherseal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.
- F. Wiring Method: Install cables in raceways.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 CONNECTIONS

- A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.
- B. Coordinate installation of utility-interactive meter with utility.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. 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.

END OF SECTION 26 31 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. Exit Signs
3. General Building
4. Miniature Emergency Inverters
5. Materials.
6. Luminaire support.

B. Related Requirements:

1. Section 26 09 23 "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-79 and IES LM-80.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

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.

2.2 DOWNLIGHT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Utopia.
 - 2. Coronet
 - 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. 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. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during maintenance 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/remote drover.
6. 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. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during maintenance 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 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.

2.4 GENERAL BUILDING

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Utopia Lighting
 - 2. HE Williams
 - 3. Visionaire Lighting
- B. Nominal Operating Voltage: 120 V -277 V ac.
- C. Lamp:
 - 1. Minimum 2,000 lm.
 - 2. Minimum allowable efficacy of 75lm/W.
 - 3. CRI: Refer to luminaire Schedule.
 - 4. Rated lamp life of 50,000 hours to L70.
 - 5. Dimmable from 100 percent to 10 percent of maximum light output.
 - 6. Internal driver.
 - 7. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.
- D. Housings:
 - 1. Extruded-aluminum.
 - 2. Powder-coat finish.
 - 3. Low-profile housing and heat sink.
 - 4. Fully gasketed and sealed. IP 65 rated.
 - 5. Stainless-steel latches.
 - 6. Integral pressure equalizer.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during maintenance and when secured in operating position.
- F. Diffusers and Globes:
 - 1. Prismatic 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.
- G. With integral mounting provisions.
- H. Standards:
 - 1. ENERGY STAR certified.
 - 2. RoHS compliant.
 - 3. UL Listing: Listed for wet location.

2.5 MINIATURE EMERGENCY INVERTERS

1. 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:
 - a. Automatic output voltage select
 - b. Automatic dimming (0-10V) relay of connected emergency luminaires under emergency lighting conditions
 - c. Switched and dimmed inputs are passed through the miniature emergency inverter to the downstream emergency luminaires under normal power conditions
 - d. Removable/replaceable electronics module
 - e. Works with LED and fluorescent fixtures
 - f. Ideal for (but not limited to) screw-base LED lamps
 - g. Compatible with AC (line voltage) driven TLED lamp
 - h. Remote-mounting up to 1,000 feet maximum
 - i. 24 hour recharge time
 - j. Minimum VA ratings of 250 VA

2.6 LUMINAIRE SCHEDULE

- A. Refer to Luminaire Schedule on Drawings.

2.7 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 56 00 - LED EXTERIOR LIGHTING

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:

1. Luminaire-mounted photoelectric relays.
2. Luminaire types.
3. Materials.
4. Finishes.
5. Luminaire supports components.

B. Related Requirements:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 26 56 13 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

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. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.

4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79 and ES LM-80.
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP 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.
 6. Wiring diagrams for power, control, and signal wiring.
 7. Photoelectric relays.
 8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
- B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
 2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Luminaires.
 2. Structural members to which luminaires will be attached.
 3. Underground utilities and structures.
 4. Existing underground utilities and structures.
 5. Above-grade utilities and structures.
 6. Existing above-grade utilities and structures.
 7. Building features.
 8. Vertical and horizontal information.
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.
- C. Retain "Product Certificates" Paragraph below to require submittal of product certificates from manufacturers.

- D. Product Certificates: For each type of the following:
 - 1. Luminaire.
 - 2. Photoelectric relay.
- E. Product Test Reports: For each luminaire, for tests performed by a qualified testing agency.
- F. Source quality-control reports.
- G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires to be included in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
 - 2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

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. Lamps: 1 for every 10 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: 1 for every 10 of each type and rating installed. Furnish at least one of each type.
 - 3. Diffusers and Lenses: 1 for every 10 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications:
 - 1. Luminaire manufacturers' 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 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.

- D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

- 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 5 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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. UL Compliance: Comply with UL 1598 and listed for wet location.

- E. Lamp base complying with ANSI C81.61.
- F. Bulb shape complying with ANSI C79.1.
- G. CRI of **70** CCT of 4000 K.
- H. L70 lamp life of 50,000.
- I. Lamps dimmable from 0-10 percent of maximum light output.
- J. Internal driver.
- K. Nominal Operating Voltage: 120 V – 277 V ac.
- L. In-line Fusing: Separate in-line fuse for each luminaire.
- M. Lamp Rating: Lamp marked for outdoor use.
- N. Source Limitations:
 - 1. Obtain luminaires from single source from a single manufacturer.
 - 2. For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Visionaire Lighting
 - 2. Zuma Lighting
 - 3. Liton Lighting
- B. Comply with UL 773 or UL 773A.
- C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
 - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
 - 2. Adjustable window slide for adjusting on-off set points.

2.3 LUMINAIRE TYPES

A. Area:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Visionaire Lighting.
 - b. Zuma Lighting
 - c. Primelite
2. Luminaire Shape: Refer to drawings.
3. Mounting: Pole/light column.
4. Luminaire-Mounting Height: Refer to drawings.
5. Distribution and run time: Refer to drawings.
6. Controls: Motion, time control and constant mode capable.
7. Diffusers and Globes: Clear polycarbonate.
8. Housings:
 - a. Extruded-aluminum housing and heat sink.
 - b. powder-coat finish.

2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Stainless steel Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during maintenance and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 2. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

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 electrical conduit to verify actual locations of conduit 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 substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Support luminaires without causing deflection of finished surface.
 - 3. 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.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

- J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 05 33 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Verify operation of photoelectric controls.
- B. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- C. Luminaire will be considered defective if it does not pass tests and inspections.
- D. 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.

3.5 DEMONSTRATION

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

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.

2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 56 00

SECTION 26 56 13 - LIGHTING POLES AND STANDARDS

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. Poles and accessories for support of luminaires.

1.3 DEFINITIONS

- A. EPA: Equivalent projected area.
- B. Luminaire: Complete luminaire.
- C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.
- D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

- A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.
 - 1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
 - 2. Include finishes for lighting poles and luminaire-supporting devices.
 - 3. Anchor bolts.
 - 4. Manufactured pole foundations.
- B. Shop Drawings:
 - 1. Include mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.

4. Anchor bolt templates keyed to specific poles and certified by manufacturer.
 5. Method and procedure of pole installation. Include manufacturer's written installations.
- C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer..
- B. Material Test Reports:
1. For each pole, by a qualified testing agency.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Sample Warranty: Manufacturer's standard warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Pole repair materials.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B660.
- B. Store poles on decay-resistant skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on poles until right before pole installation. Handle poles with web fabric straps.
- D. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturers may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-6-M.
- B. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.
- C. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.
- D. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.
- E. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.
 - 1. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is mph 90 (40 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 25 years.
 - c. Velocity Conversion Factor: 1.0.
- F. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

- G. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 ALUMINUM POLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Visionaire Lighting.
 - 2. Zuma Lighting
 - 3. HE Williams
- B. Poles: Seamless, extruded structural tube complying with ASTM B221, Alloy 6061-T6, with access handhole in in pole wall.
 - 1. Shape: Round, tapered.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- D. Fasteners: Stainless steel size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- E. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.
- F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.

- G. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected by Architect from manufacturer's full range.

2.3 POLE ACCESSORIES

- A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 26 27 26 "Wiring Devices."
1. Surface mounted 12 inches (300 mm) above finished grade.
 - a. NEMA 250, Type 3R, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.
 - b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.
- B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

2.4 MOUNTING HARDWARE

- A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi (380 000 kPa).
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
 2. Refer to drawing details.
 3. Threading: Uniform National Coarse Class 2A.
- B. Nuts: ASTM A563, Grade A, Heavy-Hex.
- C. Washers: ASTM F436, Type 1.
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
 2. Manufacturer Recommendation for washer(s) provided per anchor bolt.

2.5 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- C. Examine roughing-in for foundation and conduit to verify actual locations of installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POLE INSTALLATION

- A. Alignment: Align poles as indicated.
- B. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 03 48 10 "Precast Concrete Lighting Pole Bases."
- C. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2 -inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

3.3 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.
- B. Steel Conduits: Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.4 GROUNDING

- A. Ground Metal Poles and Support Structures: Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundation.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- 1. Inspect poles for nicks, mars, dents, scratches, and other damage.
- 2. System function tests.

END OF SECTION 26 56 13

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.

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. Product Data: For each type of product.

1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.

B. 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.

1.8 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. Connecting Blocks: One of each type.
 2. Device Plates: One of each type.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop 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.

1.10 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.
- 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 UTP 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:
- 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 6A, 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.

2.4 UTP CABLE HARDWARE

- 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:
- 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. Simon 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 6A. 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 6A performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.

2.5 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: Two-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.

2.6 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.

2.7 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."

2.8 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-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.

- E. Cable will be considered defective if it does not pass tests and inspections.
- F. 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. 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.
- E. Group connecting hardware for cables into separate logical fields.

F. 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. Administration Class: 1.
 - 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Comply with requirements in Section 099100 "Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.
- E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of comprehensive final schedules for Project.
- F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- G. 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.
 6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
- H. 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 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 6A, 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.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

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 the Elm Street Elementary School, provide a fire alarm voice notification module for connections to speaker strobes in renovated areas. Connect voice module to the existing fire alarm control panel. Extend existing fire alarm system as required to incorporate fire alarm work shown on the floor plans. Provide addressable devices as shown on drawings and all wiring. Provide programming for all devices.
2. Existing Fire Alarm in an addressable system. The main panel is a Faraday MPC-6000.

- 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 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.
- 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.
 - 2. Technician:
 - a. 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.

3. 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.

4. 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.

5. 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.

6. 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. Field quality-control reports.
- G. 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.

1.7 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).

1.8 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.

1.9 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building. 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.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

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. Fire-extinguishing system operation.

- 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. Activate emergency shutoffs for gas and fuel supplies.
 8. 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.
3. Sensor range (normal, dirty, etc.).

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 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall mounting and are complete with matching doorplate.
 - 1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
 - 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 - 3. Rating: 120-V ac.
 - 4. May be controlled directly from the FACP or remotely via a local unswitched 120 volt circuit controlled by an addressable interface device.
- B. Material and Finish: Match door hardware.

2.11 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.

2.12 ADDITIONAL FIRE ALARM DEVICES

A. Additional fire alarm devices not indicated on drawings, the devices below can be added at any time during construction up to and including project final inspections, base bid price to include device, wiring and programming.

1. Include in bid price, material and labor to wire (3) 3 phase air handling units addressable relays interfaced to existing motor starters for fire alarm fan shut down. Assume wiring lengths of 50' from motor to nearest Signal Line Circuit. Wiring is to be on a per device basis.
2. Include in bid price, material and labor to install (6) new duct smoke detectors in existing air handling equipment and wire said detectors, assuming wiring lengths of 50' from device to nearest Signal Line Circuit. Wiring is to be on a per device basis.
3. Include in bid price material and labor to install (4) new smoke detectors in existing storage spaces and wire said detectors, assuming wiring lengths of 50' from device to nearest Signal Line Circuit. Wiring is to be on a per device basis.
4. Include in bid price material and labor to install (6) new smoke detectors in existing spaces and wire said detectors, assuming wiring lengths of 50' from detector to nearest Signal Line Circuit.
5. Include in bid price material and labor to install (4) new fire alarm pull stations in existing spaces and wire said pull stations, assuming wiring lengths of 50' from device to nearest Signal Line Circuit. Wiring is to be on a per device basis.
6. Include in bid price material and labor to install (4) new fire alarm strobe lights in existing spaces and wire said strobe lights, assuming wiring lengths of 50' from strobe to nearest Notification Appliance Circuit. Wiring is to be on a per device basis.
7. Include in bid price material and labor to install (4) new fire alarm speaker\strobes in existing spaces and wire said horn\strobe, assuming wiring lengths of 50' from device to nearest Signal Line Circuit, Wiring is to be on a per device basis.

2.13 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. 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.
 - 3. Completely check, program and adjust all new and existing equipment on each system.
 - 4. 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. Repair all damaged surfaces upon removal of existing devices and raceway. Repair and patch existing construction to match existing finishes.
- Q. 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.
- R. Wire the Notification Appliance Circuits such that the audible alarm indicating devices can be turned off while the visual alarm notifications remain operational.
- S. Locate audible/visible signaling devices in strict accordance with requirements of Americans with Disabilities Act (ADA).
- T. 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.
- U. 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.
- V. 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.
- W. Device Location-Indicating Lights: Locate in public space near the device they monitor.

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 activate emergency shutoffs for gas and fuel supplies.

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. Provide complete set of battery test results for panels including:
 - a. Charger output voltage under normal conditions.
 - b. Charger output current under normal conditions.
 - c. Open battery voltage.
 - d. Supply voltage and current under primary power failure.
 - e. Supply voltage and current under primary power failure and system alarm that has activated all of panel's audible, visual and control circuits.
 - f. Calculations using battery test data obtained to determine minimum battery capacity of 24 hours under normal conditions and 5-minute alarm condition.
4. 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.
5. 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.
6. Test visible appliances for the public operating mode according to manufacturer's written instructions.
7. 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 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.11 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. Stripping and stockpiling topsoil.
 - 4. Removing above and below-grade site improvements.
 - 5. Disconnecting, capping or sealing, and removing site utilities.
 - 6. Temporary erosion and sedimentation-control measures.
 - 7. 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 Construction Manager and and notify 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. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises in location to be determined by Owner.
- D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
- F. 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.
- G. Do not direct vehicle or equipment exhaust towards protection zones.
- H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
- I. 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 [**or to be relocated**]. 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. Owner will arrange to shut off indicated utilities when requested by Contractor.
- B. 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 and Architect not less than three working days (3 days) in advance of proposed utility interruptions.
- C. 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, 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'.

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 foundations, 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 01 32 00 - Construction Progress Documentation
2. Section 03 30 00 - Cast-in-Place Concrete
3. Section 31 10 00 - Site Clearing
4. Section 32 92 00 - Turf and Grasses
5. 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. Authorized additional excavation and replacement material will be paid for according to changes in the Work.
 - 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 1557, 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. 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.

- 4. 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.

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.

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. 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

- G. 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

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. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. 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 STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
 1. Excavate by hand 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. Protect trees and other plants in accordance with requirements in Division 1 Section "Temporary Facilities and Controls" and Division 31 Section "Erosion and Sedimentation Control".

3.9 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.10 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".

3.11 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.

3.12 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.

3. Foundations: Proof-roll prior to excavation for foundations but after top soil is stripped.
- B. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities without additional compensation.

3.13 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.

3.14 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.

3.15 SOIL STABILIZATION FABRIC

- A. Install soil stabilization fabric: After subgrade has been compacted and proof-rolled, install soil stabilization fabric as specified by the manufacturer, including the following:
 1. Lay fabric in the direction of traffic.
 2. Overlap fabric side to side and end to end a minimum of two feet.
 3. Insure that fabric lies flat during fill placement.

3.16 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.

3.17 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. 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.
- D. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- E. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.18 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 building slabs:
 - a. Use structural fill below subbase layer. For subbase, use No. 2 Crushed Stone. See Drawings for depth.
 - 5. Under footings and foundations:
 - a. Use structural fill.

- 6. 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.

3.19 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.

3.20 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 structures, steps, and pavements :
 - a. Scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 - 2. Under walkways:
 - a. Scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.
 - 3. 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.

4. Utility trenches:
 - a. Compact each layer of initial and final backfill soil material at 85 percent.
5. Landscape Planting Areas:
 - a. Compact each layer of subgrade backfill or fill soil material at 75 percent.
6. 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.

3.21 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.

3.22 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 SUB BASE FOR CONCRETE SLABS-ON-GRADE

- A. Place sub base on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact sub base under cast-in-place concrete slabs-on-grade as follows:
 1. Place sub base 8 inches or less in compacted thickness in a single layer.
 2. Place sub base that exceeds 8 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 8 inches thick or less than 3 inches thick.
 3. Compact each layer of sub base to required cross sections and thicknesses to not less than 95 percent of maximum dry density according to ASTM D 4254.

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 D 698 Standard 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 and silt fence.
 - b. Off site sediment tracking controls.
 - c. Seeding and sodding
 - d. Temporary protection for existing vegetation.
 - e. 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. Soil stabilization fabric for off-site sediment tracking control, Wheel washing equipment.
6. 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. No. 4 stone for off site sediment tracking control.
 - 5. 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 STRAW BALES

- A. Shall be clean, free of dirt, hay, grass, or weeds.
- B. Bound with twine or wire.
- C. Bales, when placed, shall be dry and capable of passing water.

2.3 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).

2.4 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.

2.5 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 STABILIZED CONSTRUCTION ENTRANCE

- A. No. 4 stone meeting the following requirements:

<u>Standard ASTM Sieve Size</u>	<u>Percent Passing by Weight</u>
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.

<u>Property</u>	<u>Unit</u>	<u>Test Method</u>	<u>Value</u>
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.

2.8 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.

2.9 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 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).

3.8 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.

3.9 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

3.10 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 principal 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. 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. Shim Course: NYSDOT No. 402.058904 (Type 5 Shim). Maximum 20% RAP permitted.
 - 6. Top Course: NYSDOT No. 402.097304 (Type 7.) Maximum 20% RAP permitted.
 - 7. Top Course: NYSDOT No. 402.097104 (Type 7F.) 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 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 or AASHTO T 245, 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.
- 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 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.
3. Joint Sealant.
4. Concrete Sealer.
5. Curing materials.
6. Joint forming materials.
7. Joint Filler.
8. Sealers
9. Detectable Warning Materials.
10. Colored Concrete.
11. Imprinted and Textured Concrete.

B. Related Sections:

1. Section 03 30 00 "Cast-in-Place Concrete" 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
9. Concrete Color Materials, Sealant, Curing Compound and Joint Sealant
10. Concrete Stamping Materials and Release Agents

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.)
- B. Qualification data for colored concrete supervisor.
- C. Qualification data for colored concrete installer.

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.
- C. For colored, textured and/or stamped concrete installer:
 1. Provide qualified supervisor that has completed at least five colored, stamped projects similar in scope to this project. Provide minimum of three references for above projects.
 2. Colored textured stamped concrete installer to be certified by approved concrete color manufacturer. Provide copy of certification to Architect.
- D. Mock-up for Colored Concrete: Provide 48"x48" minimum size mock-ups for each color, texture and finish. Location to be designated by Architect and Owner. Do not proceed with remaining work until workmanship, color and finish are approved by Architect. Refinish mock-ups as required to produce acceptable work.

1.8 PREINSTALLATION MEETING

- A. Concrete Paving Preinstallation Conference: Conduct conference at Project site.
 - 1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - 2. Review concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction joints, forms and form-removal limitations, reinforcement accessory installation, concrete repair procedures, and protection of cast-in-place architectural concrete.

1.9 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 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.
- B. Colored / Stamped Concrete Curing Compound: Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class 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:
 - 2. BASF Construction Chemicals - Building Systems; Kure-N-Seal 25 LV.
 - 3. ChemMasters; Spray-Cure & Seal Plus.
 - 4. Meadows, W. R., Inc.; CS-309/30.

2.5 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.
- B. Colored/Stamped Concrete Sealer: Solvent-Borne, Membrane-Forming Sealing Compound: To be compatible with integral and color-hardened concrete system.
 - 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, www.master-builders-solutions.basf.us/en-us/contact
 - b. The Bomanite Company, www.bomanite.com
 - c. L.M. Scofield Company, www.scofield.com

2.6 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.
 - 2) Color for colored concrete: Custom color to match colored concrete.
 - b. W.R. Meadows, Inc.; Deck-O-Seal Sealant.
 - 1) Color for uncolored concrete: Stone Gray.
 - 2) Color for colored concrete: Custom color to match colored concrete.

2.7 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.

2.8 INTEGRALLY COLORED CONCRETE

- A. Color Pigment: Refer to Div 03 concrete section for integral concrete coloring product requirements.
 - 1. Color: As selected by Architect from manufacturer's full range.
- B. Colored Concrete Sealer: Solvent-Borne, Membrane-Forming Sealing Compound - To be compatible with integral and color-hardened concrete system.
 - 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. The Bomanite Company, www.bomanite.com
 - b. L.M. Scofield Company, www.scofield.com

- C. Colored Concrete Curing Compound: Solvent-Borne, Membrane-Forming Curing and Sealing Compound in accordance with ASTM C 1315, Type 1, Class A. For use with stamped concrete only.

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 - Building Systems; Kure-N-Seal 25 LV.
 - b. ChemMasters; Spray-Cure & Seal Plus.
 - c. Meadows, W. R., Inc.; CS-309/30.

2.9 PIGMENTED COLOR HARDENER

- A. Pigmented Mineral Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

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. The Bomanite Company, www.bomanite.com
 - b. L.M. Scofield Company, Lithochrome system, www.scofield.com

2. Color: As selected by Architect from manufacturer's full range.

- B. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

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, LLC; Mastercron.
 - b. ChemMasters; ConColor.
 - c. Dayton Superior Corporation; Quartz Tuff.
 - d. Lambert Corporation; COLORHARD.
 - e. Scofield, L. M. Company; LITHOCHROME Color Hardener.

2. Color: As selected by Architect from manufacturer's full range.

2.10 IMPRINTED CONCRETE MATERIALS

- A. Imprinting Tools: Mat type imprinting tools for texturing freshly placed concrete, in multiple patterns and textures as selected by Architect from full range of patterns and textures.

1. Refer to plans for patterns and textures.

- B. Imprinted Concrete Liquid Form Release Agent: Dissipative form release agent, manufactured by or compatible with coloring system.
 - 1. Finish: Clear or “antique” finish, as chosen by Architect.
 - 2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. The Bomanite Company, www.bomanite.com
 - b. L.M. Scofield Company, www.scofield.com

2.11 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.

2.12 CONCRETE MIXTURES

- A. Refer to Div 03 concrete section for concrete mixtures.
- B. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

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. 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.
- L. 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.
- C. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surface according to manufacturer's written instructions and as follows:
1. Uniformly spread dry-shake hardener at a rate of 100 lb/100 sq. ft., unless greater amount is recommended by manufacturer to match paving color required.

2. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
3. After final power floating, apply a hand-trowel finish followed by a broom finish.
4. Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

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 or curing and sealing compound for stamped concrete per manufacturer's instructions. Do not use silicane sealer on stamped concrete.

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 31 13 - CHAIN LINK FENCES AND GATES

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. Chain-link fences.
 - 2. Gates: Swing.
 - 3. Privacy Slats.
- B. Related Sections:
 - 1. Section 03 30 00 "Cast-in-Place Concrete"
 - 2. Section 31 20 00 "Earth Moving"

1.3 REFERENCES

- A. ASTM A392 Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
- B. ASTM F552 Standard Terminology Relating to Chain Link Fencing.
- C. ASTM F567 Standard Practice for Installation of Chain Link Fence.
- D. ASTM F626 Specification for Fence Fittings.
- E. ASTM F900 Specification for Industrial and Commercial Swing Gates.
- F. ASTM F1083 Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
- G. ASTM F1184 Specification for Industrial and Commercial Horizontal Slide Gates.
- H. CLFMI WLG2445 Chain Link Fence Wind Load Guide for the Selection of Line Post and Line Post Spacing.

1.4 PERFORMANCE REQUIREMENTS

- A. Design Wind Load: Comply with applicable requirements of building code in effect for Project including applicable portions of ASCE 7 for Wind Load Pressure and CLFMI WLG 2445 Wind Load Guide for the Selection of Line Post Spacings.

1.5 SUBMITTALS

- A. General: Submit all action submittals (except Samples for Verification) and informational submittals required by this Section concurrently.
- B. Action Submittals:
 - 1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
 - a. Fence and gate posts, rails, and fittings.
 - b. Chain-link fabric, reinforcements, and attachments.
 - c. Polymer and polyester coatings.
 - 1) Note: Polymer and polyester coated samples and product data are to be submitted simultaneously.
 - d. Accessories:
 - 1) Privacy slats
 - e. Gates and hardware.
 - 2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
 - 3. Samples for Verification:
 - a. Polymer and Polyester Coated Components: In 6-inch lengths for components and on full-sized units for accessories.
 - 1) Note: Polymer and polyester coated samples and product data are to be submitted simultaneously.
 - b. Manufacturer's color charts.
 - 4. Warranty:
 - a. Sample of special warranty
 - b. Sample of manufacturer warranty
- C. Informational Submittals:
 - 1. Qualification Data: Submit list of completed projects using products proposed for this Project, including owner's contact and telephone number for each project, demonstrating compliance with "Quality Assurance" article.
 - 2. Product Test Reports: For framing strength according to ASTM F 1043.

D. Closeout Submittals:

1. Operation and Maintenance Data: For the following to include in operation and maintenance manuals:
 - a. Polymer and polyester finishes.
 - b. Gate hardware.
2. Warranty: Executed special warranty.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Minimum five (5) years' experience in installing chain link fences and gates similar in material, design, and extent to that indicated for this Project in accordance with ASTM F 567, whose work has resulted in construction with a record of successful performance.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.8 WARRANTY

- A. Special Warranty: Contractor's warranty to repair or replace components of chain-link fences and gates that fail in materials or workmanship within the specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Failure of any component of fence to perform as designed.
 - b. Faulty operation of gate(s) to perform as designed.
 2. Warranty Period: Five (5) years from date of Substantial Completion.
- B. Manufacturer warranty: Manufacturer's standard form in which Contractor agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Deterioration of metals, metal finishes, coatings and other materials of the fence components, including fabric, framework and fittings.
 2. Warranty Period: Fifteen (15) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle. Comply with CLFMI Product Manual and with requirements indicated below:
1. Fabric Height: As indicated on Drawings.
 2. Steel Wire Fabric:
 - a. General Use: Wire with a diameter of 0.148 inch (9 gauge) minimum. For polymer coated fabric, wire with a diameter of 0.148 inch core (9 gauge core) minimum.
 3. Mesh Size:
 - a. General Use: 2 inches, unless noted otherwise.
 4. Coatings:
 - a. Polymer-Coated (Vinyl) Fabric: ASTM F 668, Table 4, Class 2b, fused and adhered over zinc-coated steel wire.
 - 1) Color: As selected by Architect from manufacturer's full range, complying with ASTM F 934.
 - 2) Basis of Design Manufacturer: Subject to compliance with requirements, polymer coating that may be incorporated into the Work include, but are not limited to, the following:
 - a) Merchants Metals Brighton Colorcoat II fused and adhered polymer coating.
 5. Selvage: Knuckled at both selvages.

2.2 FRAMEWORK MATERIALS

- A. Posts and Rails: Comply with ASTM F 1043 for minimum dimensions and wall thickness of framing, including rails, braces, and line; terminal; and corner posts, meeting the following criteria:
1. Heavy Industrial Strength: ASTM F 1043 Group I-C, SS40, round steel electric-resistance-welded pipe galvanized with hot-dip process in accordance with ASTM A653/A653M and ASTM A924/A924M.

2. Manufactured to meet minimum yield strength of 50,000 psi and coated in accordance with the following standards:
 - a. ASTM F1043, Group IC, Electrical Resistance Welded Round Steel Pipe, heavy industrial weight.
 - b. M181, Type I, Grade 2, Electrical Resistance Welded Steel Pipe
 - c. RR-R 191/3, Class 1, Grade B, Electrical Resistance Welded Steel Pipe.

B. Coatings:

1. Zinc Coating:
 - a. Zinc coating to conform to ASTM B6 and the weight range (external and internal) of ASTM F1043, Type B. Exterior surface of the weld to be recoated with the same material and thickness as the basic zinc coating.
 - b. Weight of the zinc to be determined through ASTM A90, 1.8 w/ PVC, 2.0 oz w/o vinyl.
 - c. Final coat to be a clear acrylic finish.
2. PVC / Polyester Coating Over Zinc Coating:
 - a. Thermoplastic vinyl finish to be 10 mils (minimum) thick.
 - b. Cleaning and Surface Preparation: Consists of a four-stage pretreatment/wash, an iron phosphate coating and immersion in a water based epoxy primer.
 - c. PVC Coating Application: Coating is thermally fused to heated pipe meeting the following standards:
 - 1) ASTM F1043 Group I-C, Heavy Industrial.
 - 2) Federal specification RR-F-191/3E, Class 1
 - 3) Shows satisfactory adhesion in cross-hatch test, Method B, ASTM D3359.
 - 4) Finish shall not crack, blister or split under normal use.
3. Color: Match chain-link fabric, complying with ASTM F 934, Standard Colors for Polymer-Coated Chain Link Fence Materials.

C. Basis of Design Manufacturer: Subject to compliance with requirements, framework and coatings that may be incorporated into the Work include, but are not limited to, the following:

1. Merchants Metals Colorbond Chain Link Fence Framework and Coating System.
2. Master Halco Permafused II Heavy Mil PVC Chain Link Fence Framework and Coating System.
3. Ameristar PermaCoat PC-40 (industrial weight), manufactured by Ameristar Fence Products (www.ameristarfence.com) Chain Link Fence Framework and Coating System.

2.3 FRAMEWORK SIZES

- A. Line Post Size (determined by height):
 - 1. 4 feet up to and including 6 feet high: 2 inches o.d.
- B. End, Corner and Pull Post:
 - 1. 4 feet up to and including 6 feet high: 2-1/2 inches o.d.
- C. Horizontal Framework Members: Intermediate, top and bottom rails complying with ASTM F 1043. Size in accordance with the following guidelines unless otherwise indicated on drawings:
 - 1. Top, Intermediate and Bottom Rail: 1.66 inches in diameter.
 - a. Bottom Rail: Provide bottom rail for:
 - 1) Fence 6 feet high and over, or as shown on drawings.
 - b. Intermediate Rail: Provide intermediate rail for:
 - 1) Fencing 6 feet high and over, or as shown on drawings.
 - 2. Brace Rails: Comply with ASTM F 1043.

2.4 FITTINGS

- A. General: Comply with ASTM F 626.
- B. Post Caps: Provide for each post. Post caps to be weather-tight, securely fastened and vandal-resistant.
 - 1. Provide line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
 - 1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.
 - 2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails in the fence line-to-line posts.
- E. Tension and Brace Bands: Pressed steel.
- F. Tension Bars: Steel. Length not less than 2 inches shorter than full height of chain-link fabric with minimum cross-section of 3/16 inch x 3/4 inch. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading. Provide rod and turnbuckle or other means of adjustment.

H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.

1. Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
 - a. General Use Fencing:
 - 1) Aluminum: ASTM B 211; Alloy 1350-H19; 0.148-inch-diameter, mill-finished wire. Coating to match chain-link fence fabric. (Provide coating to match framework.)

I. Fitting Finish:

1. Steel or cast iron: Galvanized Coating for Pressed Steel or Cast Iron - Not less than 1.2 oz. /sq. ft. zinc.
 - a. Coating - Vinyl-coated per ASTM F 626. Coating to match framework.
2. Aluminum: Mill finish with coating to match framework.
3. Color: To match color of fence fabric.

J. Fasteners:

1. Material to be stainless steel.
 - a. Coating - Vinyl-coated per ASTM F 626. Coating to match framework.
2. Color: To match color of fence fabric.
3. Finish: Install fasteners that are no more than ¼ Inch long.

2.5 SWING GATES

A. General: Comply with ASTM F 900 for gate posts and single and double swing gate types.

1. Gate Leaf Width: 48 inches unless otherwise noted on drawings.
2. Gate Fabric Height: As indicated on drawings.

B. Pipe and Tubing:

1. Coating and finish to match fence framing.
2. Gate Post Size:
 - a. For gate heights over 6', and if gate height is equal to fence height, then standard fence framing end post requirements shall apply. Refer to Post and Rail requirements.
 - b. Gate Leaf up to 6 feet Wide: 2.875 inches o.d.; 4.64 lbs./l.f.

- c. Gate Leaf over 6 feet and under 12 feet wide: 4 inches o.d.; 6.56 lbs./lin. ft. (weight applicable to Group IC SS40 framework only)

C. Frame Corner Construction: Welded.

D. Swing Gate Hardware:

1. Hinges: 180-degree inward swing unless otherwise noted on Drawings.
2. Latches: Commercial latch permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Padlock and Chain: Owner furnished.
4. Keeper: Provide keeper for all vehicular gates, which automatically engages gate leaf and holds it in open position until manually released. Provide sleeve to insert keeper. For concrete paving, set sleeve directly into concrete. For asphalt paving set sleeve into concrete collar.
5. Double Gates: Provide drop bar for all double gates, consisting of hot-dipped galvanized rod that drops into concrete collar. Provide locking device and padlock eyes as an integral part of the latch, requiring one padlock for locking both gate leaves.
6. Closer: Manufacturer's standard.
7. Color: To match fence fabric.

2.6 PRIVACY SLATS – 90 Percent Coverage

A. Material: Heavy duty polyethylene reinforced tubular slats with “wings”:

1. Provide 90% coverage.
2. Slats must span full height of fence (i.e., no partial height slats).
3. Slat Width: 1 7/16” for 2” Mesh Size.
4. Manufactured for chain-link fences from virgin polyethylene containing UV inhibitor.
5. Sized to fit mesh specified with vandal-resistant fasteners and lock strips.
6. Installed vertically.
7. Verify wind-loading is appropriate for fencing specified and application.

B. Color: As selected by Architect from manufacturer's full range.

2.7 CONCRETE

A. Concrete Footings: Refer to Division 03 concrete section for cast-in-place concrete, ASTM F 567 Section 5 and Drawings and Details for footing size. Bottom of footing must not be smaller than the top to prevent frost heaving.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 - 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- 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. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

- A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
 - 1. Install fencing on established boundary lines inside property line.

3.4 CHAIN-LINK FENCE INSTALLATION

- A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil. Mechanically driven posts only allowed if shown on Drawings or specifically approved by Architect.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - a. Concrete Fill: Minimum 28-day compressive strength 3,000 psi (20 MPa). Refer to Division 03 Section "Cast-in-Place Concrete."
 - b. Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
- C. Types of Post Footings: As indicated on Drawing or as approved by Architect.
 - 1. Concealed Concrete: As indicated on Drawings to allow covering with surface material.

- D. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.
- E. Line Posts:
1. General Use Fencing: Space line posts uniformly at 10 feet o.c. unless otherwise indicated on Drawings.
- F. Post Bracing, Bottom and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
1. Locate horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps / loop caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps / loop caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer. Connection sleeves to be located / supported by post caps / loop caps.
- H. Intermediate and Bottom Rails: Install and secure to posts with fittings.
- I. Chain-Link Fabric: Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
1. Height of fabric between finished grade and bottom selvage.
 - a. General Use: Leave 1 ½ inches between finished grade or surface and bottom of selvage unless otherwise indicated.
 2. Fabric installation on fence posts relative to adjacent use:
 - a. General Use: Apply fabric to outside of enclosing fence posts / framework as indicated on Drawings.
- J. Tension or Stretcher Bars: Thread bar through first row of diamonds of fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.
- K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Aluminum ties: Both ends of the tie are to make two complete wraps around wire pickets. Bend ends of wire to minimize hazard to individuals and clothing.
1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 18 inches o.c.
 2. Privacy Slats: Install slats in direction indicated, securely locked in place, vertically.

3.5 SWING GATE INSTALLATION

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.6 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain chain-link fences and gates.

3.8 COMPLETION AND CLEAN UP

- A. Leave the area of installation free of debris and excess soil, concrete, and gravel resulting from installation of the fence. Clean fencing of concrete slurry, hydroseeding overspray and any other excess material. Seed and mulch all areas around the fencing where bare earth is left exposed.

END OF SECTION 32 31 13

SECTION 32 50 00 - BOLLARDS

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. Pre-fabricated bollards.
 - 2. Bollard covers.

1.3 SUBMITTALS, GENERAL

- A. General: Submit all action submittals (except Samples for Verification) and informational submittals required by this Section concurrently.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Pre-fabricated bollards.
 - 2. Bollard covers.
- B. Shop Drawings: Show fabrication and installation details for bollards.
 - 1. Include plans, elevations, sections, and details of bollards and their connections. Show anchorage and accessory items.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pre-Fabricated Metals Bollards Warranty: Provide manufacturer's standard limited warranty that the bollards will remain free from defects in material and workmanship including cracking, peeling, blistering and corroding for a period of three years from date of purchase.

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify actual locations of construction contiguous with bollards by field measurements.

1.7 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

2.2 FERROUS METALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Steel Tubing: ASTM A 500, cold-formed steel tubing.

2.3 FASTENERS

- A. General: Unless otherwise indicated, provide Type 304 Type 316 stainless-steel fasteners. Select fasteners for type, grade, and class required.

2.4 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
- B. Acrylic Primer: Thermoplastic acrylic primer compatible with topcoat.
 - 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. Rust-Oleum Corporation; 3200 System Clear Blue Undercoat.

- C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- D. Concrete: Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete with a minimum 28-day compressive strength of 3,000 psi.

2.5 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply 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. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

2.6 BOLLARD COVERS

- A. Plastic Bollard Cover: Heavy duty plastic bollard cover that fits over standard site-fabricated steel bollard.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Ideal Shield, Plastic Bollard Cover, 1/4" thick polyethylene or comparable product.
 - 2. Materials: 1/4" thick UV resistant and anti-static LDPE plastic sleeve, domed at top
 - 3. Sleeve for pipe diameter: 6 inch.
 - 4. Color: Architect to choose from full range of standard colors. Color warranted for five years.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Beginning installation constitutes Contractor's acceptance of substrates and conditions.
- B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- C. Coordinate location to avoid utilities.
- D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- E. Field Welding: Comply with the following requirements:
 - 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. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 INSTALLING FABRICATED METAL BOLLARDS

- A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.
- B. Anchor bollards in place with concrete footings. Center and align bollards in holes 12 inches above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured. Set bollard plumb.

3.3 INSTALLING PLASTIC BOLLARD COVERS

- A. Install with manufacturer's neoprene adhesive tape per manufacturer's installation guidelines.

3.4 ADJUSTING AND CLEANING

- A. Touchup Painting: Provide touchup painting in conformance with Section 09 96 00, "High Performance Coatings".
- B. Clean all surfaces thoroughly and protect until acceptance.

END OF SECTION 32 50 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. Turf planting soil.
 - 4. Turf planting soil amendments and fertilizers.
 - 5. Turf renovation.
 - 6. Turf
 - 7. 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. Imported Topsoil.
- B. Samples for Verification: For the following products, in sizes or quantities indicated below:
 - 1. Imported and On-Site 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.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- B. Qualification Data: For qualified landscape Installer.
- C. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- D. Material Test Reports:
 - 1. Imported Topsoil: Before delivery, submit written statement giving location of properties from which topsoil is to be obtained, names and addresses of property owners, analysis of topsoil, 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. Turf Installer: Engage an experienced turf installation firm to perform work of this Section that has installed at least seven (7) acceptable projects of the type specified within past 5 years. Provide location and reference contacts for each of the submitted projects.
 - 2. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor with certifications outlined below on Project site when work is in progress.

4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Turfgrass Professional, designated CTP.
 - b. Certified Turfgrass Professional of Cool Season Lawns, designated CTP-CSL.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, 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 plant-nutrient content of the soil; map with locations where each sample was collected; date, time and weather when samples were collected; and name of person who collected the samples.
 1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for turf growth.
 - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1,000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

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, lime, 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. 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. Seed Blends: Seed blend with not less than 95 percent germination, not less than 85 percent live seed, and not more than 0.5 percent weed seed.
1. If premixed blend, follow manufacturer's recommended maximum seeding rate unless otherwise noted.

C. Lawn Seed:

1. 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.

D. 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 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*).

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 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 FERTILIZERS

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. 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 4 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.

2.4 TURF PLANTING SOILS

- A. General: Provide turf planting soil consisting of existing and/or imported topsoil with amendments and fertilizers noted in this Section. Unamended existing or imported topsoil is not acceptable as turf planting soil.
 - 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 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.
- C. 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.
1. Provide soil analysis per requirements in Part 1 of this Section.
- D. 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.
1. 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 brome grass; 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.
 2. Provide soil analysis per requirements in Part 1 of this Section.
- E. Required Amendments: Mix existing and imported topsoil with the following soil amendments in the following quantities to produce planting soil:
1. pH Adjustment: Apply approved calcium or sulfur compounds to correct pH level to be between 6.5 and 7.5 or as recommended by soil analysis report.
 2. Soil Analysis Recommendations: Provide nutritional and other amendments recommended in the soil analysis report, as approved by Architect.
 3. Provide fertilizer per "Fertilizer" Article above.

2.5 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

2.6 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 grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 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.
- C. 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.
- 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.
 - 2. In larger areas, including athletic fields if approved by Architect, mulch by hydromulching.
- F. Water newly planted areas and keep moist until new turf is established.

3.5 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.

3.6 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 Postfertilization: Apply fertilizer after initial mowing and when grass is dry.

3.7 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, brown spots, 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.

3.8 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. Drains.
4. Frames and grates/lids
5. Catch basins.
6. Stormwater Manholes.

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.

- 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/storm inlets 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.
- B. Interior Diameter, 4" to 30": Corrugated polyethylene circular pipe with silt-tight joints and 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 M 294-Type S or SP
 2. Mannings "n" Value: 0.010.
 3. Fittings: AASHTO M252 or M294.
 4. Joints: Meeting AASHTO Standard Specification for Highway Bridges, Section 26 paragraph 26.4.2.4(e). Silt tight – meeting ASTM D1056 Grade 2A2.
 5. Materials: ASTM 3350 minimum cell classification 324420C (4" to 10") or 335420C (12" to 30").
 6. Similar to "Hi-Q Pipe" by Hancor, Inc.; Findlay, Ohio.

2.2 PERFORATED SINGLE WALL HDPE CORRUGATED PIPE:

- A. Interior Diameter, 3" to 24": Corrugated perforated single wall polyethylene circular pipe with uniform slots and drilled holes complying with the following specifications:
1. Applicable Standards:
 - a. 3 inch to 10 inch pipe: AASHTO M 252
 - b. 12 inch to 24 inch pipe: AASHTO M294
 2. Fittings: Meet performance requirements of ASTM D 3034 and ASTM F 1336. Gaskets to comply with ASTM F477.
 3. Manufacturer: Similar to "Perforated Single Wall Plastic Corrugated Pipe" by Advanced Drainage Systems, Inc.; London, Ohio.

2.3 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.

2.4 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.

2.5 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 flat grate with small square or short-slotted drainage openings.

- 1. Size: 24-in by 24-in minimum unless otherwise indicated.
- 2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

- C. 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.

2.6 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, Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, 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.

2.7 STORMWATER MANHOLES– 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

2.8 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.

2.9 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 36-inch minimum cover.

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 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.

3.5 CATCH BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

3.6 CONCRETE PLACEMENT

- A. Place and test cast-in-place concrete according to ACI 318 and Division 03 concrete section.

3.7 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.

3.8 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.

3.9 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. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

- A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION 33 41 00

SECTION 34 71 13.26 – VEHICLE GUIDE RAILS

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. New box-beam guiderails, posts and component parts where indicated on Drawings.
- B. Related Sections:
 - 1. SECTION 31 10 00 - Site Clearing
 - 2. SECTION 31 20 00 - Earth Moving
 - 3. SECTION 32 12 16 - Asphalt Pavement
 - 4. SECTION 03 30 00 - Cast-in-Place Concrete

1.3 SYSTEM DESCRIPTION

- A. Design Requirements
 - 1. Box-beam Guidedrails: Comply with applicable requirements of New York State Department of Transportation (NYSDOT) "Standard Specifications" (January 2, 1981) including following:
 - a. Section 606 "Guide Railing"
 - b. Section 710-21 "Box Beam Guide Railing and Median Barrier"

1.4 SUBMITTALS

- A. Comply with requirements of SECTION 01 33 00 - Submittals and as modified below.
- B. Product Data: Submit manufacturer's product data indicating compliance with standards referenced herein.
- C. Shop Drawings: Submit shop drawings indicating layout of guardrail installation, dimensions of guardrail section, and details of installation showing mounting heights, depth of post below grade and other details.
- D. Contract Closeout Submittals: Submit maintenance and cleaning instructions as item in "General Construction Instructions" manual described in SECTION 01 77 00.

PART 2 - PRODUCTS

2.1 BOX BEAM GUIDERAILS

A. Components

1. Rails: Cold-formed, welded and seamless structural tubing of sizes and dimensions indicated on drawings and conforming to ASTM A500, Grade B as modified in Section 710-21 NYSDOT "Standard Specifications". Provide galvanizing complying with requirements of Section 719-01, Type I, NYSDOT "Standard Specifications."
 - a. Connection Holes and Splicing Holes: Factory fabricated and re-galvanized in accordance with Section 710-21, NYSDOT "Standard Specifications". Splices lapped in direction of traffic.
2. Posts: American Standard Beam Section of sizes and dimensions indicated on drawings. Posts, splice tongues, plates and all hardware fabricated and ready for assembly before galvanizing.
 - a. Posts, Splice Tongues, and Plates: Conform to ASTM A36 and galvanized in accordance with Section 719-01, Type I, NYSDOT "Standard Specification".
 - b. Hardware: Galvanized in accordance with Section 719-01, Type II, NYSDOT "Standard Specifications".
3. Fasteners
 - a. Bolts and Nuts: Conform to ANSI B 18.2.1 and ANSI B 18.2.2.
 - b. Washers: Conform to ANSI B 18.22.1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Erect posts, railing, end assemblies and rail transitions in positions and manner indicated on drawings. Comply with requirements of Section 606-3, NYSDOT "Standard Specifications".
- B. Posts: Driven in accordance with Section 606-3, NYSDOT "Standard Specifications" and aligned to tolerance of 1/4" for plumb and grade line.
- C. Rail Splices: Not less than 18 ft. on center; minimum 18" from centerline of any post.

3.2 CLEANING

- A. Upon completion of installation, remove all debris and surplus material. Restore surrounding grass areas and site improvements damaged or soiled as a result of this guide rail installation.

END OF SECTION 34 71 13.26